THE
GLASS
INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING

Optical Society Meets In Canada

● THE FALL MEETING of the Optical Society of America was held at the Chateau Laurier, Ottawa, Canada, October 8, 9 and 10. During the three day session over eighty papers were presented and the following notes were made of topics of interest to the glass industry.

Automatic Recording Spectrapolarimeter

H. Rudulph and R. Bruce of Rudulph Instruments Engineering Company described a spectropolarimeter capable of recording rotary dispersion curves through the wavelength range from 210 mμ to 680 mμ.

Fiber Optics

Interest continued in bundles of glass fibers for transmitting optical information. Eight papers related to this one subject were given. Some of the less apparent applications described were the use of fibers to produce high aperture lenses for photography, the use of short fibers for face plate in oscilloscopes, and the use of fibers for the measurement of weak absorption bands. Also presented were several papers on the mathematics of model glass fibers.

Vacuum Ultraviolet

A symposium of four invited papers on vacuum ultraviolet spectroscopy shows a considerable interest in this region of the spectrum. Papers reviewed the new coatings available for high reflectance in this region, solar spectroscopy from rockets, and the molecular information to be gathered in the vacuum ultraviolet.

Far Infrared Properties of Quartz and Sapphire

E. Lowenstein of Johns Hopkins University obtained transmission spectra of quartz and sapphire in the wavelength region beyond 100 microns. Values for the complex index were obtained.

Diffuse and Total Reflectance in the Infrared

R. R. Sawyer and C. C. Helms of Perkin Elmer described a double beam instrument to measure reflectance with samples in the temperature range from 400°C to 1100°C.

General

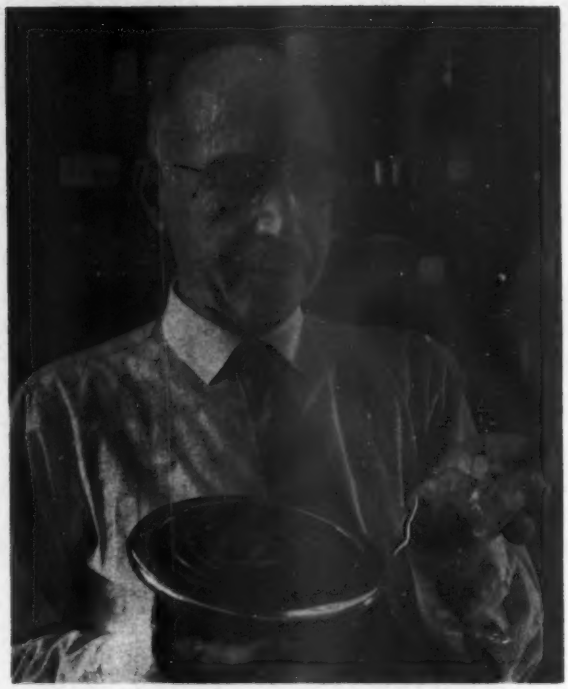
The Ives Medal for 1959 was presented to Dr. W. E. K. Middleton for outstanding work related to atmospheric optics.

Dr. A. H. Zimmerman, chairman of the Defense Research Board of Canada, was the guest speaker. His topic was "Science and National Defense."

The Society members visited the laboratories of the National Research Council, the spectroscopy laboratories of the Mines Branch of the Department of Mines and Technical Surveys, and the Dominion Observatory.

—Dr. R. Meltzer, Bausch & Lomb Optical Co.

Louis Navias . . .



Dr. Navias, holding fused magnesia crystals (Periclase) and a Calrod unit in which fused magnesia is used as insulation between the external metal sheath and the heating helix inside. Behind him are glass-front cabinets displaying a continuous record of his years of work in the glass and whiteware fields.

The 1960 Toledo Glass and Ceramic Award will be presented to Dr. Louis Navias, of the General Electric Research Laboratories, Schenectady, N.Y. on January 18 at a dinner in the Commodore Perry Hotel, Toledo, Ohio. This award is presented annually by the Northwestern Ohio Section of the American Ceramic Society "to accord recognition for scientific or engineering achievement with broad interpretation."

● IN THE OFFICE of Dr. Navias there are two glass-front cabinets whose shelves are laden with little bottles, boxes, wooden racks, and just plain objects—all related to his years of work in the glass and whiteware fields. Enough specimens to furnish a museum.

In one corner are "exploded views" of electron tubes, with the parts cemented to sheets of heavy cardboard and handwritten inscriptions in ink indicating the years in which design changes were made.

On another shelf is a cutaway Calrod heating unit, one of the oldest, with its coiled heating element and the magnesium oxide packing clearly visible. Dr. Navias and Dr. O. G. Vogel refined the composition of the Calrod unit (about 1939) by adding silica to the MgO, thereby improving its electrical resistivity and making it easier to fuse.

Here, too, is a short "history" of the silent mercury switch, with the development of its parts illustrated on a sheet of cardboard. It was Dr. Navias who developed the refractory ceramic for the switch in which the expansion characteristics of the refractory had to match those of both the surrounding glass and metal—a magnesia-clay mixture, properly fired, did the trick.

Then there is a cutaway glass-and-metal bushing, the size of a hand, designed for use in transformers (Dr. Navias developed the borosilicate glass), and there are samples of his work on glass-to-metal seals, subsequently used on wide scale in electron tubes.

Long ago his collection overflowed into the outer office where, in cardboard cartons, there are bits of broken chinaware—half teacups, broken saucers, chipped plates and shattered vases—all topics of conversation which help lead visitors (non-ceramists) into discussions on just what ceramics are and what they can do.

Out of a desk drawer will come a collection of glass buttons, gathered over the years when Dr. Navias was investigating the earlier successes man had had in creating useful glass-to-metal seals.

Dr. Navias began working at General Electric in 1924 as a research associate in the research laboratory. As a ceramic chemist, he was in charge of the ceramic research and development work which covered new ceramic materials in porcelain, enamel, glass, and refractories to meet the requirements of advanced engineering designs. Much of his ceramic work at that time was devoted to insulators used in electronic tubes and radio, television, radar and power developments.

Since his retirement in 1954, he has been Consultant on Ceramics in the Metallurgy and Ceramics Research Department.

Born in Grodno, Russia, in 1897, he received his secondary education in Johannesburg, South Africa. After coming to America, he obtained his Bachelor of Science Degree from the City College of New York (1918) and then went to work for Bausch & Lomb Optical Company (1918-1920). His early work in the two-year period covered chemical analysis of glass and glass-making materials. He later became responsible for quality control problems in connection with the manufacture of optical glass.

He left Bausch & Lomb to enter the University of Illinois for further study, under Dr. Washburn, where he obtained his M.S. (1921) and Ph. D. (1923) in Ceramic Chemistry, while doing important work on the properties of silica. In 1923 and 1924 he was employed as an expert in the Ceramic section of the U. S. Tariff Commission. Immediately following this, he joined General Electric.

The profile of Dr. Navias would not be complete were we to overlook his important work in technical societies, as well as his impressive role as an author (26 manuscripts) and as an inventor (17 patents).

He has taken an active part in three divisions—Whiteware, Glass and Basic Science—of the American Ceramic Society. He became a regular member of the Society in

...1960 Toledo Award Winner

1919; a Fellow in 1931; served as Chairman of the Publications Committee from 1933 to 1935; Glass Division Secretary (1944); Glass Division Chairman (1945); Research Committee Chairman (1955-56; 1956-1957; 1957-58; 1958-1959; 1959-1960); Vice President of the Society in 1956-57; and Distinguished Lecturer (1957).

He joined the American Chemical Society in 1920, became Secretary of the Eastern New York Section in 1930, and served as Chairman of that Section from 1931 to 1932.

Dr. Navias became a member of Committee D-9 on electrical insulating materials of the American Society for Testing Materials in 1928 and from 1937 through 1944 served as Secretary to Committee C-14 on glass and glass products. Thereafter, from 1944 through 1948, he was Chairman.

Sigma Xi: Has been a member since 1921.

American Association for the Advancement of Science: Has been a member since 1924 and a Fellow since 1925.

The Ceramic Association of New York: Director (1949). President (1957-1958, 1958-1959, 1959-1960). He is the first person who has ever served for three terms as President of the 26-year-old Association.

Society of Glass Technology (England): Became a member in 1948.

He was a Priestley Lecturer at Pennsylvania State University in 1929 and a participant in the Second International Congress on Glass (1936) in England.

He became a professional engineer in New York State in 1953.

Although he is a very serious person who does not dwell on things of a light nature, he does have a keen sense of humor. He admits he may have become widely known through his many contributions to the technology of the electrical manufacturing industry, although sometimes the identification has been a bit imprecise. At his desk, he will show you one envelope, yellowing now with age, addressed to "Louis N. Ceramic," another to "Rev. Louis Navias" (the cause for confusion between ceramics and theology, he explains, is obscure, unless Man is considered made of clay), and finally an envelope addressed confidently to "Mr. L. Navias, President, General Electric Company."

He has played the piano for many years and quite often joins in duets with colleagues from the laboratory. Favorites among his composers are Mozart and Beethoven.

On the local scene, in Schenectady, N.Y., Dr. Navias has become widely known as the "Johnny Appleseed of the Manchurian Willow" (Salix Matsudana Contorta). Dr. Navias first introduced these twisted non-weeping type willows into the Schenectady area in 1952 when he obtained a cutting from a professor at Cornell; because of his persistent enthusiasm for this tree, the local landscape now boasts quite a number of them.

This intense interest he carries over into everything he does. Through his unstinting diligence and devoted pursuit of scientific knowledge, Dr. Louis Navias has made many important contributions to the advancement of science through his work in ceramics.

It is most fitting, therefore, that the Northwestern Ohio Section of the American Ceramic Society has selected him as the 1960 recipient of the Toledo Glass and Ceramic Award.

LIST OF PAPERS

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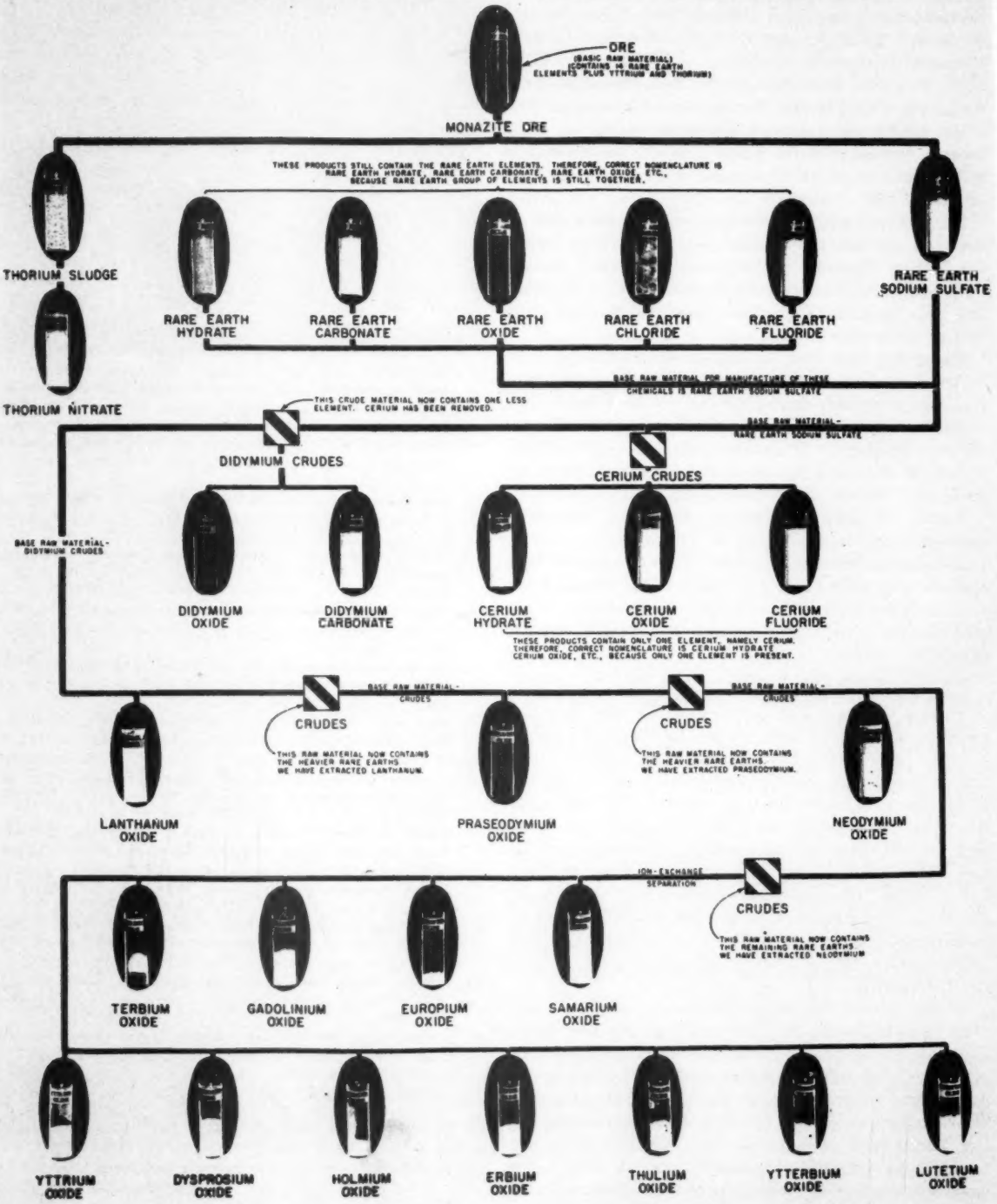
2. **The Products of the Calcination of Flint and Chalcedony.** E. W. WASHBURN AND LOUIS NAVIAS, Journal of the Amer. Cer. Soc., **5** (9), 565-585, Sept. 1922.
3. **Measurements of the Heat Absorbed and Evolved by Clays During Firing and Cooling.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **6** (12), 1268-1298, Dec. 1923.
4. **Quantitative Determination of the Development of Mullite in Fired Clays by an X-ray Method.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **8** (5), 296-302, May 1925.
5. **Study of Segregation in Porcelain Filter Cake by Petrographic Methoods.** LOUIS NAVIAS, Jour. of the Amer. Soc., **8** (7) 432-436, July 1925.
6. **Metal Porosimeter for Determining the Pore Volume of Highly Vitrified Ware.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **8** (12), 816-821, Dec. 1925.
7. **Differentiation Between Mullite and Sillimanite by Their X-ray Diffraction Patterns.** LOUIS NAVIAS AND W. P. DAVEY, Jour. of the Amer. Cer. Soc., **8** (1) 640-647, Oct. 1925.
8. **Methods of Testing and the Physical Properties of Wet-Process Electrical Porcelain.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **9** (8), 501-510, Aug. 1926.
9. **A Simple 'Sealed-in Mercury Electrode' Apparatus for Testing the Breakdown Voltage of Heavy Insulating Materials.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **9** (9), 598-605, Sept. 1926.
10. **Impact and Static Transverse Strength of Wet Process Electrical Porcelain.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **10** (2), 90-97, Feb. 1927.
11. **Scratch Hardness Tests of Ceramic Materials.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **12** (2), 69-74, Feb. 1929.
12. **Rate of Drying of a Plastic Porcelain Mass Due to Reduced Pressure and Heat.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **12** (5), 305-318, May 1929.
13. **Selenium Dioxide as a Constituent of Glasses.** LOUIS NAVIAS AND JOHN GALLUP, Jour. of the Amer. Cer. Soc., **14** (6), 441-449, June 1931.
14. **Welded Zigzag Windings and Refractory Shapes for High-Temperature Furnaces.** LOUIS NAVIAS, Jour. of the Amer. Cer. Soc., **14** (5), 365-375, May 1931.
15. **Porcelain and Allied Ceramic Bodies.** LOUIS NAVIAS, in Colloid Chemistry by JEROME ALEXANDER, Vol. III (1931) 197-350.
16. **Crushing and Fine Grinding of Quartz.** LOUIS NAVIAS in Colloid Chemistry by JEROME ALEXANDER, Vol. III (1931) 157-178.
17. **Extrusion of Refractory Oxide Insulators for Vacuum Tubes.** LOUIS

(Continued on page 47)

FLOW SCHEME
THORIUM AND RARE EARTH CHEMICALS


ORE
(BASIC RAW MATERIAL)
(CONTAINS 14 RARE EARTH ELEMENTS PLUS YTTRIUM AND THORIUM)
MONAZITE ORE
THESE PRODUCTS STILL CONTAIN THE RARE EARTH ELEMENTS. THEREFORE, CORRECT NOMENCLATURE IS RARE EARTH HYDRATE, RARE EARTH CARBONATE, RARE EARTH OXIDE, ETC., BECAUSE RARE EARTH GROUP OF ELEMENTS IS STILL TOGETHER.
THORIUM SLUDGE
THORIUM NITRATE
RARE EARTH HYDRATE
RARE EARTH CARBONATE
RARE EARTH OXIDE
RARE EARTH CHLORIDE
RARE EARTH FLUORIDE
RARE EARTH SODIUM SULFATE
BASE RAW MATERIAL FOR MANUFACTURE OF THESE CHEMICALS IS RARE EARTH SODIUM SULFATE
THIS CRUDE MATERIAL NOW CONTAINS ONE LESS ELEMENT. CERIUM HAS BEEN REMOVED.
BASE RAW MATERIAL - RARE EARTH SODIUM SULFATE
DIDYMIUM CRUDES
CERIUM CRUDES
BASE RAW MATERIAL - DIDYMIUM CRUDES
DIDYMIUM OXIDE
DIDYMIUM CARBONATE
CERIUM HYDRATE
CERIUM OXIDE
CERIUM FLUORIDE
THESE PRODUCTS CONTAIN ONLY ONE ELEMENT, NAMELY CERIUM. THEREFORE, CORRECT NOMENCLATURE IS CERIUM HYDRATE CERIUM OXIDE, ETC., BECAUSE ONLY ONE ELEMENT IS PRESENT.
BASE RAW MATERIAL - CRUDES
CRUDES
THIS RAW MATERIAL NOW CONTAINS THE HEAVIER RARE EARTHS WE HAVE EXTRACTED LANTHANUM.
BASE RAW MATERIAL - CRUDES
CRUDES
THIS RAW MATERIAL NOW CONTAINS THE HEAVIER RARE EARTHS WE HAVE EXTRACTED PRASEODYMIUM.
LANTHANUM OXIDE
PRASEODYMIUM OXIDE
NEODYMIUM OXIDE
ION-EXCHANGE SEPARATION
CRUDES
THIS RAW MATERIAL NOW CONTAINS THE REMAINING RARE EARTHS WE HAVE EXTRACTED NEODYMIUM
TERBIUM OXIDE
GADOLINIUM OXIDE
EUROPIUM OXIDE
SAMARIUM OXIDE
YTTRIUM OXIDE
DYSPROSIUM OXIDE
HOLMIUM OXIDE
ERBIUM OXIDE
THULIUM OXIDE
YTTERBIUM OXIDE
LUTETIUM OXIDE

THE RARE EARTHS

by Clifford A. Hampel, CONSULTING CHEMICAL ENGINEER, SKOKIE, ILL.

Part One

THE RARE EARTH ELEMENTS—also called the "rare earths" or "lanthanides"—are a group of fifteen elements placed in Group III of the periodic table because of their remarkably similar chemical properties. They have atomic numbers of 57 to 71, inclusive, and resemble yttrium, scandium and actinium found in the same group. One outstanding property is their high heat of formation and, hence, the great stability of their oxides which makes them very useful in the glass and ceramic industry.

Table I lists the rare earth elements and yttrium, giving atomic number, atomic weight, melting point, density, typical valences, oxide formulas and their classical distribution in cerium, terbium and yttrium groups. Although not a rare earth, the element yttrium is included with them because of its general occurrence with rare earths in ores and similarity in properties to them.

Applications in the Glass Industry

About one-quarter of the rare earth chemicals produced are used in the glass industry, with cerium compounds accounting for the greater portion. Cerium and other rare earth compounds have important uses in:

1. The decolorization of glass.
2. The coloring of glass.
3. The preparation of glasses that are opaque to ultraviolet and other types of light, such as the yellow sodium light encountered in glass blowing and welding.
4. Cerium oxide is a preferred material for polishing glass.
5. Lanthanum oxide is used in silica-free optical glass with a high refractive index.

Other Applications

A second quarter of the rare earth chemicals is used in carbon arc lighting where a white light is desired. Here they are present in the cores of carbons for arc lights so vital to the motion picture industry, both in studio and theatre projection. The searchlights of the Army, Navy and Coast Guard also use rare earth-cored carbons. The light quality from such carbons closely matches the color of natural sunlight.

A third quarter of the commercially produced rare earths is converted to, and used in, the metallic state. This includes misch metal, an alloy of cerium and other rare earths, containing about 45-50 per cent Ce, 22-25 per cent La, 15-17 per cent Nd, and 8-10 per cent other rare earth metals. This alloy has been a commercial product since the early 1900's. Pyrophoric iron—misch metal alloys used as spark metals for lighter flints, etc., contain 18-30 per cent iron, the iron being necessary for hardness. Other commercial rare earth metals comprise cerium metal; didymium metal, an alloy of the cerium-free rare earths; lanthanum metal; neodymium-praseodymium metal; and lanthanum-enriched misch metal, all of which have been marketed since the 1940's. The high-purity individual rare earth and yttrium metals have become commercially available only in the last year or two. Their availability offers a host of applications in the chemical, metal and electronic industries.

The metals are derived chiefly from the corresponding rare earth chlorides, or their mixtures, which after careful dehydration are electrolyzed in the anhydrous fused state. The electrolysis is conducted in the presence of fused NaCl, KCl or $CaCl_2$ in a cast iron pot

TABLE I

THE RARE EARTHS AND YTTRIUM

Element	Atomic Number	Atomic Weight	Melting Point °C	Density g/cc	Valences	Oxide (Ignited in Air)		
Lanthanum	57	138.92	920±5	6.162	3	La_2O_3	Cerium group	"light" rare earths
Cerium	58	140.13	804±5	6.768	3,4	CeO_2		
Praseodymium	59	140.92	935±5	6.769	3,4	Pr_6O_{11}		
Neodymium	60	144.27	1024±5	7.007	3	Nd_2O_3		
Promethium	61	145.			3	Pm_2O_3		
Samarium	62	150.43	1052±5	7.540	2,3	Sm_2O_3		
Europium	63	152.0	826±10	5.245	2,3	Eu_2O_3	Terbium group	"heavy" rare earths
Gadolinium	64	156.9	1350±20	7.868	3	Gd_2O_3		
Terbium	65	159.2	1450±50	8.253	3,4	Tb_4O_7		
Dysprosium	66	162.46	1485±20	8.565	3	Dy_2O_3		
Holmium	67	164.94	1500±25	8.799	3	Ho_2O_3	Yttrium group	
Erbium	68	167.2	1500±25	9.058	3	Er_2O_3		
Thulium	69	169.4	1600	9.318	3	Tm_2O_3		
Ytterbium	70	173.04	824±5	6.959	2,3	Yb_2O_3		
Lutetium	71	174.99	1700±50	9.849	3	Lu_2O_3		
Yttrium	39	88.92	1500±25	4.472	3	Y_2O_3		

Table II

TYPICAL ANALYSES OF COMMERCIAL RARE EARTH ORES

	Monazite (Idaho)	Bastnasite Conc. (California)
La_2O_3	17%	24.6%
Ce_2O_3	29.9	47.1
Pr_2O_3	3.9	4.4
Nd_2O_3	11	12.6
Sm_2O_3	1.3	0.7
Eu_2O_3	0.001	
Gd_2O_3	0.5	
Other terbium group oxides	0.2	0.5
Yttrium group oxides	0.1	
Y_2O_3	0.9	
Total rare earth oxides + Y_2O_3	64.8	89.9
ThO_2	3.5	0.1
MgO	0.1	
CaO	0.3	
BaO		
$Al_2O_3 + Fe_2O_3$	0.6	
TiO_2	0.2	
ZrO_2	0.1	10.0
F		
P_2O_5	28	
SiO_2	1	
SO_3		
Loss on ignition		

which serves as the anode. Graphite cathodes suspended in the melt complete the electrolytic circuit. Initially external heating is used to maintain the temperature; however, the electrolysis generates enough heat to keep the temperature above the melting point of the metal. The metal collects in a pool at the bottom of the pot, from which it is withdrawn and cast into ingots.

The high-purity individual metals are prepared by reduction of the corresponding anhydrous chloride or fluoride with calcium metal in a suitable container under an inert gaseous atmosphere.

Consumption of the remaining quarter of the rare earths is divided among a multitude of miscellaneous applications, one example being that of control rods for nuclear reactors where the high thermal neutron absorption cross sections of gadolinium, samarium, dysprosium, europium and, to a lesser extent, erbium are of value.

Occurrence

The most important sources of the rare earths are monazite, a rare earth-thorium phosphate, found in both massive deposits and sands, and bastnasite, a fluocarbonate mineral. Table II gives typical analyses of commercial monazite and bastnasite ores.

Monazite sand results from the weathering of acid granites and pegmatized gneisses followed by concentration into beach and dune deposits by the action of wind and water. Ilmenite, zircon, rutile and quartz usually are found with it. By physical methods of separation, (gravity and electromagnetic), almost pure monazite may be concentrated from these sands. Beach placer deposits are found in Travancore, India; Espirito Santo, Rio de Janeiro; Bahia, Brazil; Jacksonville, Florida; and Australia. Stream placer deposits have been exploited in Idaho and North and South Carolina.

A massive monazite deposit in the Van Rhynsdorp district of the Union of South Africa currently supplies most of the United States requirements for monazite.

The bastnasite deposits of San Bernardino, California constitute a very large reserve capable of supplying the rare earth industry for many years. Thus, the United States need not be dependent upon foreign sources for the rare earths.

Inasmuch as monazite is the major source of thorium, valuable as a source of fuel for atomic power, the rare earth industry is associated to some degree with the present and potential demands for thorium. Prior to about 1925 monazite was processed primarily for thorium oxide for Welsbach mantle use, but since about 1932 thorium has become a by-product as the demand for the rare earths increased. Because of the restrictions on data concerning the total amount of thorium compounds being produced, it is not known exactly what this relationship is today.

The relative abundances of the rare earths as commercial products are almost directly proportional to the concentrations of them in the ores listed in Table II.

It is of interest to note that the rare earths, among other elements, are formed by the fission of uranium and plutonium. Indeed, the fission products from atomic piles are the only source of promethium, element 61, which was discovered and first isolated by ion-exchange from the rare earths produced by fission.

Derivation

As might be expected when dealing with a raw material of the complex composition of the rare earth minerals, the extraction of high-purity products from the above ores is difficult. Since monazite is the chief source

(*Continued on page* 48)

Table III

APPROXIMATE PRODUCTION CAPACITY AND COSTS OF RARE EARTHS

Material	Production Capacity, lb/year (as oxides)	Purity, % contained oxide	Cost,* $/lb
Cerium oxide	1,500,000		
$CeO_2 \cdot xH_2O$ (hydrate)		83	1.40
CeO_2		90	1.90
CeO_2		99.9	5.00
Lanthanum oxide	700,000		
La_2O_3		99.5	5.85
Neodymium oxide	500,000		
Nd_2O_3		85	2.10
Praseodymium oxide	170,000		
Pr_6O_{11}		80	20.00
Pr_6O_{11}		99	30.00
Samarium oxide	45,000		
Sm_2O_3		80	20.00
Sm_2O_3		90	25.00
Sm_2O_3		99	45.00
Gadolinium oxide	25,000		
Gd_2O_3		80	30.00
Gd_2O_3		90	35.00
Gd_2O_3		99	90.00
Dysprosium oxide	20,000		
Dy_2O_3		99	50.00
Erbium oxide	8,000		
Er_2O_3		99	50.00

*The above prices are for lots of 500 pounds or more.

FLAT GLASS
(An N.B.S. Report)

● THE FLAT GLASS INDUSTRY embraces all branches of the glass industry engaged in manufacturing and distributing glass in the form of plates or sheets and it manufactures about a third of the dollar value of all glass produced. Major products of the industry are window, plate, safety, figure, and wire glass. The principal users are the automotive, aircraft, and other transportation industries, which account for at least 50 per cent of the value of total output; the construction industry (residential, commercial, schools, hospitals, etc.), which is the second major user; and the furniture industry (mirrors, table tops, etc.), which accounts for most of the remaining consumption.

Trends in 1959

In the first nine months of 1959, production of sheet glass in terms of quantity increased 38 per cent over the same period for 1958, and 36 per cent over 1957. Production of plate glass in the first nine months of 1959 was 43 per cent and 24 per cent above the corresponding periods of 1958 and 1957.

Comparative statistics for 1957, 1958, and 1959 (first 9 months) are based on Bureau of Census data (in 1,000 square feet) in Table I.

Imports of flat glass reached an all-time high in 1959, topping the previous record of $45.6 million in 1956. They declined to $31.2 million in 1957, and then increased to $35.6 million in 1958. However, during the first 9 months of 1959, imports totaled $48.2 million, an increase probably caused by a strike in the flat glass field which affected a major producer during the latter part of 1958 and early 1959. According to the Bureau of the Census, imports for the last 3 years were as shown (in millions of dollars) in Table II.

TABLE I

	1957		1958		1959 (1st 9 Mos.)	
	Sheet	Plate	Sheet	Plate	Sheet	Plate
1st Qtr.	244,250	172,968	268,700	133,195	282,900	186,680
2nd Qtr.	222,350	148,976	210,600	99,108	352,250	223,003
3rd Qtr.	263,650	148,645	238,700	175,126	354,900	174,951
4th Qtr.	318,900	182,308	190,850	113,909		
Total	1,049,150	652,897	908,850	521,338		

Although current trends in imports indicate a decline in the last half of 1959, imports should exceed 1958 by approximately 69 per cent and 1957 by approximately 92 per cent. The dollar value of imports as a percentage of total consumption increased from 6.0 per cent in 1957 to 7.2 per cent in 1958 and may reach 10 per cent for 1959. The greatest dollar volume of imports is in sheet and plate glass. Mirrors, rolled, and laminated glass are secondary. In 1957, sheet glass accounted for 45 per cent of total imports of flat glass, but in 1958 and the first nine months of 1959 it increased to 56 per cent. Plate glass represented 45 per cent of total flat glass imports in 1957 and then declined to 32 per cent in 1958 and the first nine months of 1959. Total consumption of flat glass for 1957-59 is as shown (value $1,000) in Table III.

The 1960 Outlook

Many factors should result in the flat glass industry increasing its 1960 production to $600 million, approximately 10 per cent above 1959. The rapid growth of the U.S. population indicates an increasing demand for more homes, commercial buildings, and automobiles—important users of flat glass.

TABLE II

	1957	1958	1959 (First 9 mos.)
Cylinder, Crown, and Sheet	$14.1	$19.9	$27.1
Plate	14.1	11.3	15.4
Mirrors	.6	.6	.9
Rolled	1.9	2.7	3.0
Laminated, etc.	.5	1.1	1.8
Total	31.2	35.6	48.2

The flat glass industry will be stimulated by the production of the new automobile models, which once again should use more glass than the preceding year. The construction industry has also joined the trend toward the use of larger glass areas as architects emphasize the use of glass for better living. Home improvement and modernization programs have increased the demand for aluminum storm windows and doors, jalousies, and glass wall partitions. The industry has emphasized product engineering and research during the past few years and several new products and uses for flat glass have been developed.

TABLE III

Year	Production	Imports	Exports	Apparent Consumption	Per Cent Imports of Consumption
1957	500,000	31,171	16,235	514,936	6.0
1958	470,000	35,626	15,047	490,579	7.2
1959 (est.)	550,000	60,000	20,000	590,000	10.1

The Carborundum Company and Harbison-Walker Refractories Company announced last month that they have pooled their advanced refractories technology and sufficient financial resources in order to establish a jointly owned subsidiary for the engineering, manufacture and sale of fused refractories. This subsidiary, known as Harbison-Carborundum Corporation, is operating Carborundum's refractory plant in Falconer, N.Y., about which this article is written.

FIG. 1. Aerial view of expanded plant.

CARBORUNDUM TRIPLES PLANT CAPACITY

by Roy W. Brown, SALES MANAGER, HARBISON-CARBORUNDUM CORP.

• THE RECENT EXPANSION that tripled the facilities of The Carborundum Company's fused-cast refractories plant at Falconer, N. Y., created major problems; however, from the start of construction until the new equipment was operative, not a single day's work was lost.

In essence, these fused-cast refractories are manufactured by mixing various dry ingredients, melting them in electric furnaces and pouring directly into molds. When the blocks partially solidify, the molds are stripped and the blocks are annealed, inspected and shipped. Unit weights range from 5 to over 3400 lbs.

Expansion work was complicated by the production of four varieties of fused-cast refractories, each with different crystalline compositions considered necessary to give balanced service in glass furnaces.

Originally, all raw materials were bagged and transported by lift trucks and manpower. A skip hoist supplied a mixer that, in turn, dumped into a box taken by lift truck to the furnace platform where the batch was shovelled into the furnace.

FIG. 2. Moving print-weigh lorry on special crane under raw material bins.

Small cars carrying molds were pushed by hand over tracks to and from the furnaces. Powder required in preannealing and annealing operations had to be shovelled manually over blocks. Lift trucks conveyed annealing boxes to the annealing, storage, cleaning, inspection and shipping areas.

FIG. 3. Special blender is charged from hopper above, discharges below.

In tripling the manufacturing facilities for these fused-cast (Monofrax) refractories, it was necessary to mechanize most of the handling system and install many additional control points in order to maintain and improve quality. Three buildings for bulk storage, annealing, and mold and pattern storage were needed.

Early in preliminary planning two major drawbacks developed:

1. Building additions would disturb existing building foundations.
2. Installation of production furnace and materials-handling equipment and construction of building additions would interrupt plant operations.

FIG. 4. Gravity feed on electric furnace.

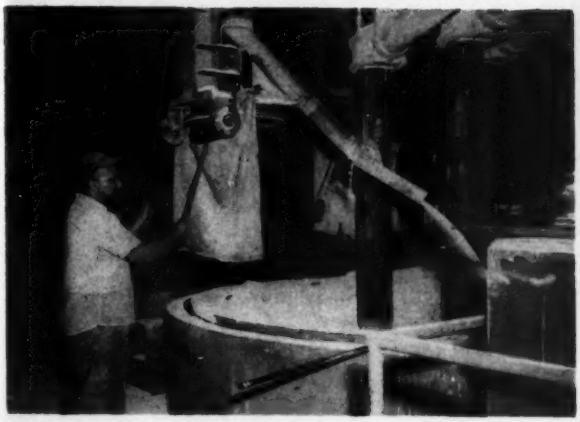


FIG. 5. Graphite mold ready for the pour.

FIG. 6. Furnace pouring in molds held by hoist suspended from a moving crane.

Working in close cooperation with Carborundum's engineers, Planet Corporation, Lansing, Mich., was responsible for the design, procurement and installation including all electrical controls, panels, field wiring, piping and the complete dust-collection system.

The first problem was to design a bulk-storage system and building for 3 million lbs. of raw materials and 1 million lbs. of weighing, batching, mixing and materials-handling equipment. Instead of adding to an existing building by the normal method of using the outside line of the original building's columns (which necessitates under-cutting to provide new supports), completely new buildings were erected adjacent to the original one, and they were later connected by removing some of the walls.

The storage building consists of a three-bin-wide system, built in as an integral part of the new structure. After control checks by either chemical or spectroscopic analysis, bulk raw materials are removed from box cars with a power scoop. (Provision was made in the design to add a track hopper and oscillating feeder to ultimately handle shipments in closed hopper-bottom cars.) Elevators lift the abrasive and dusty raw materials (60 to 300 mesh) 40 feet to an oscillating conveyor system on top of the bins.

This type of conveyor "pitches" and "catches" the raw material and is designed so that pressure and motion do not occur at the same time. The pan is withdrawn as the material lights, which makes the catch a very gentle cradling action. Dusting and pan wear from abrasion is minimized, as is iron pickup by the batch itself. Raw materials sliding down the pan by gravity would increase abrasive action at least four-fold.

For quality control, each carload of raw material goes into one of nineteen separate bins connected by 180 feet of conveyors.

A special elevator and handling system is used for chrome ore which is processed separately throughout the plant to eliminate contamination of other batches.

Required raw materials are discharged from the bins into hoppers on a weighing platform (Fig. 2) mounted on a special bridge-crane-weigh lorry. Minor ingredients are checked on smaller, more sensitive scales. Printed weight tickets, prepared for each batch, give a second control point. After weighing, the bridge crane is positioned to discharge the batch into special buckets at floor level. Then a mixer operator, located on an overhead platform, uses a motorized hoist and monorail to transport the buckets to V-shaped blenders (Fig. 3) that are used instead of the usual mixers.

The blenders have automatic electronically timed controls with set rotating and blending times. The operator controls the valve that discharges the batch into buckets on an automatic conveyor sysem. These buckets are then taken to the assigned furnace area by lift trucks.

Here the batch is lifted into overhead furnace hoppers that have moveable spouts to feed the batch uniformly by gravity (Fig. 4) over the entire melting area. The new furnaces have controls that print records of power input, voltage and furnace-cycle times.

Each melt has individual behavior during furnacing; separate procedures are detailed to obtain desired oxidation, fluidity, removal of gas and homogenization of the melt. At the discretion of process control, sample 9-inch

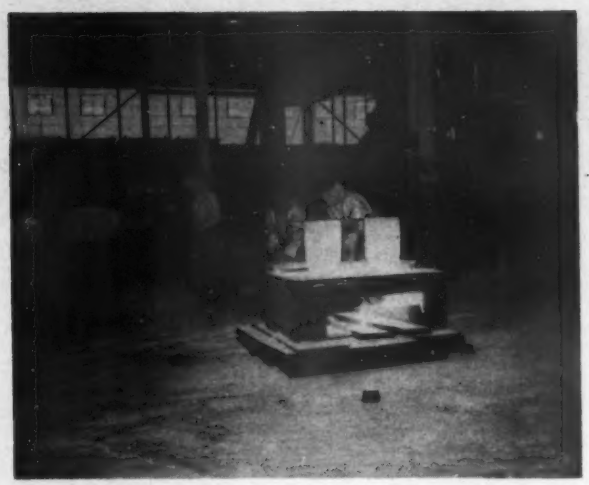


FIG. 7. Stripping graphite mold from an "M" feeder channel.

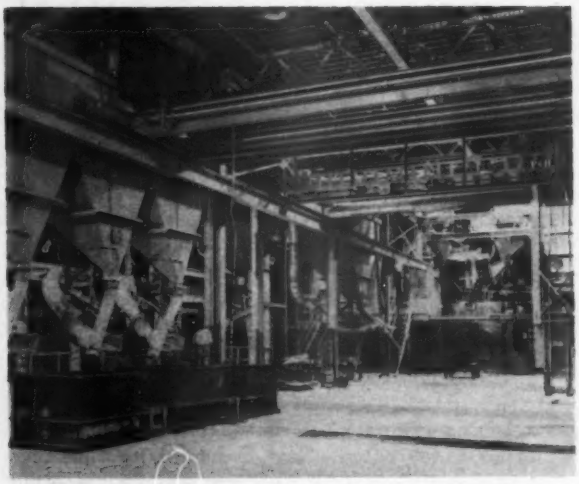


FIG. 8. Annealing system. Blocks are poured, stripped and placed in annealing bins (left) where they are covered with annealing ore from overhead bins.

cubes are frequently poured for testing internal structure and density.

For the pouring operation, the furnace operator can move the mold-holding unit in six directions. This tends to keep the header well centered on the stream of molten material, thereby minimizing spillage outside or splash inside the molds. The stream has a temperature range of 3300°-3700°F.

The mold holder employs a special bridge crane using a 5-ton motorized-trolley hoist mounted on a 10-ton bridge. Specially designed, vertically telescoping forks handle the mold pallets during pouring. In the event of an accident—which would have damaged mold car, rails and mechanism in the old system—spillage now falls to the floor or, at worst, hits the easily replaceable forks.

Mechanization of the molding, pouring, pre-annealing and annealing operations was the next major phase.

Original plans called for installation of the pattern, mold make-up and maintenance department in a new building. It was subsequently decided to place the annealing department in the new building with a much higher roof, and leave the pattern and mold make-up departments in the existing structure. This approach made it possible to install equipment with no effect on production.

When the equipment was ready to be used, the direction of material flow through the plant was changed.

After the molds, which are made from either graphite or bonded-alumina grain, are assembled (Fig. 5), the inspection and quality control departments check them for accuracy. They are then taken to the furnace area where they are handled by the overhead conveyor crane during pouring and pre-annealing.

The casting operation demands extreme care. After pouring a fused-cast refractory (Fig. 6), a void usually forms in the block as the material goes from liquid to crystalline state. Two relatively new techniques tend either to minimize difficulties arising from the void, or eliminate the void altogether. The first involves tilting the mold while pouring, handling and annealing. The void moves toward the high point of the casting as does the bubble in a spirit level. (The block is installed with the void in the least vulnerable location.)

FIG. 9. Annealing building. Blocks are cooled in ore about two weeks.

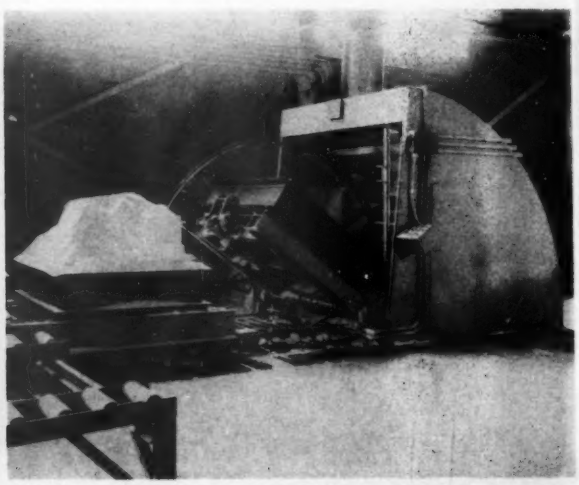


FIG. 10. Box dump area. Annealed products and ore are separated.

A second technique involves casting the block with an extra large permanent header that remains on the block during the annealing operation. The block is tilted to allow the void to rise into the header, and the block and header assembly is carried through the entire annealing program. The extra large header containing the void is diamond sawed from the shape just before inspection and shipment.

Following pouring, the mold is moved away from the furnace and is stripped (Fig. 7) when solidification has progressed to the point at which the block can be handled safely. A steel shield is placed around the block which is immediately covered with annealing ore.

The annealing material must be placed over the blocks as soon as possible. Carborundum and Planet engineers decided on the use of overhead-storage bins because the fast-acting electrical gates provide ore quickly. Rapid mechanized-block handling is necessary owing to the speed with which the outside surface of the block crystallizes. Minute-by-minute schedules are determined by process engineering for blocks of all sizes, shapes and compositions. There is little or no viscosity range to these melts. Surface stresses can result which reduce the thermal-shock resistance and mechanical strength of the blocks.

At this point, a relatively large magma of molten bath is maintained in the block's center. Slow crystallization of this liquid releases enough heat to stress relieve the insulated outside portions.

When the melt level in the header has lowered sufficiently to minimize void formation, the pre-anneal shield is removed and the block is carried by overhead crane to a large annealing bin (Fig. 8) and again covered with ore. Here the remaining header is broken off from the block in the regular or tilted position, or as previously mentioned, in the "voidless" blocks, the headers may be retained through annealing and ultimately cut off by a diamond saw. The bin is then carried and stacked in the annealing building (Fig. 9) where it remains for approximately 2 weeks while the block slowly cools to room temperature. This entire building was designed for eventual overhead moving cranes.

After the annealing cycle, the bin is placed on a 36-foot indexing conveyor that leads to an area where the block is lifted out by an overhead crane hoist. The bin is clamped and rotated roughly 135° to discharge all of the annealing ore (Fig. 10).

Underneath the indexing conveyor and box dump, three oscillating-conveyors transport the ore back to a screening area where it is elevated, screened and delivered to storage by balanced oscillating overhead conveyors. Fourteen conveyors are used in this system.

The block is then moved through the cleaning and inspection area where excess annealing ore is removed and tests for weight and dimensional accuracy are made (Fig. 11). In this area, blocks can be sawed or drilled with diamond tools if extra finishing operations are required. On this portion of the operation, there is 100 per cent inspection. Every block is marked with its weight (Fig. 12) and checked for flatness, warpage and other physical details. The blocks move on pallets by fork trucks to the assembly, crating and shipping areas Fig. 13).

(*Continued on page* 51)

FIG. 11. Inspection for dimensional accuracy on an "H" port jamb.

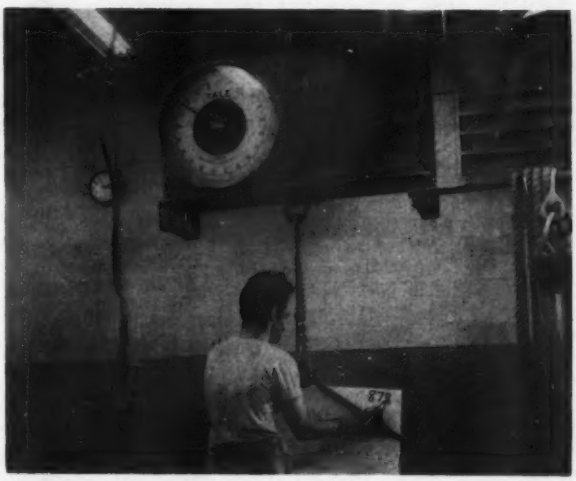


FIG. 12. Recording weight on an "S" tank block.

FIG. 13. Portion of block storage area. Grinding, diamond sawing areas are in background.

Nickel and Cobalt Films *by Samuel Wein,* CONSULTANT

Part Four

● AN ANONYMOUS INVENTOR through the Indian Council of Scientific and Industrial Research forms an alloy of nickel and cobalt on glass, mica, wood and Bakelite by using the following solution:

Nickel sulphate, 10%	25-30 c.c.
Cobalt chloride, 2% of the nickel sulphate	100 c.c.

Sodium hydrosulphite is then gradually dropped into the solution with gentle agitation. This addition is stopped when the green solution is slightly yellowish in color. Allowing the pieces to be coated to remain in the solution for 20 to 25 minutes at 23 to 30° C. It is then washed and dried, and the process repeated to form a thicker nickel-cobalt film.

The thin nickel-cobalt film so formed may be electroplated from a Watt's nickel solution.

Dr. Kise modified the foregoing technique by using a 10 per cent sodium hydrosulphite solution, which was covered by xylene to protect it from the air, this was introduced from a tip of the burette placed below the surface of the nickel solution. The theoretical quantity of a 10 per cent solution of sodium hydrosulphite was 66 cc. per 100 cc., of a 10 per cent nickel sulphate solution.

In several laboratory tests, from 60 to 80 cc. of sodium hydrosulphite solution was used to obtain a yellowish end point. The yellow end point in the previous reference is difficult to detect because of the finely divided black nickel in suspension in the liquid. The nickel deposit formed a dull film which would probably serve as a satisfactory base for subsequent electro-deposition.

It might be added that the sodium hydrosulphite solution was added under the surface of the nickel solution to prevent excessive localized reaction and decomposition in the air.

Pessel formed alloys between nickel and cobalt by using the following two-reducer solution:

	Parts
Cobalt acetate (1%)	10
Nickel formate (1%)	10
Sodium hypophosphite (Sat. Sol.)	2
Hydrazine hydrate (85%)	2

"Electroless Cobalt"

Metallic cobalt and alloys of cobalt and nickel films may likewise be formed on silvered surfaces.

Curtius and Schrader have precipitated cobalt with hydrazine as well as with hydroxylamine from ammoniacal solutions.

Browne and Shetterly too have studied the effect of hydrazine on cobalt solutions from an academic viewpoint.

Cobalt reduction from concentrated sodium hypophosphite solutions containing a trace of palladium was studied by Paal and Frederici as well as by Scholder and Haken, and by Scholder and Heckel.

To Dr. Brenner and Miss Riddell belongs the honor and credit for bringing to us the rich contributions they have made in formulating what now appears to be a commercial method of forming cobalt films. One such solution consists of:

	Grams 1 Liter
Cobalt chloride	30
Sodium hypophosphite	20
Sodium citrate	35
Ammonium chloride	50

Ammonium hydroxide is used for neutralizing the solution. The pH best found is between 9 and 10. The appearance of the deposited cobalt is dull. The rate of deposition per hour is 0.015 mm. which is equivalent to 0.0006".

In their patent they give the chemical reaction as:

$$CoCl_2 + NaH_2PO_2 + H_2O \rightarrow Co + 2HCl + NaH_2PO_3 \quad (1)$$

Concurrently, some of the sodium hypophosphite is oxidized by the water, particularly in the presence of certain metals, to phosphite, and hydrogen is liberated:

$$NaH_2PO_2 + H_2O \rightarrow NaH_2PO_3 + H_2 \quad (2)$$

A simplified solution recommended by these contributors consists of:

	Parts By Weight
Cobalt chloride	0.125— 2.5
Sodium hypophosphite	0.7 —10.7
Water	50 —98.5

The temperature range is between 90° and 100° C.

Bergstrom recommended the use of either acid or alkaline solutions of cobalt solutions using a 1 to 10 per cent (by weight) of pyrogallol, a reducing agent.

Pessel used two reducing agents, i. e.: hydrazine hydrate and sodium hypophosphite in the following fashion.

	Parts
Example 1	
Cobalt acetate (1%)	10
Sodium hypophosphite (Sat. Sol.)	1
Hydrazine hydrate (85%)	1
Example 2	
Cobalt acetate (1%)	10
Ammonium hydroxide (Sat. Sol.)	1
Sodium hypophosphite (Sat. Sol.)	1
Hydrazine hydrate (85%)	1

Cobalt-Nickel Alloy Films

Dr. Brenner and Miss Riddell produced excellent films of an alloy between nickel and cobalt which is worthy of serious consideration. The solution used consisted of:

	Grams Per Liter
Nickel chloride	30
Cobalt chloride	30
Sodium hypophosphite	20
Rochelle salts	200
Ammonium chloride	50

Ammonium hydroxide was the source of alkali recommended for neutralizing the solution the pH of which was between 8 and 10. The rate of deposition in mm. was 0.015 (0.0006) per hour. The appearance of the deposit was semi-bright.

CHEMICALS USED

Herewith follows in alphabetical order the compounds referred to in the various processes reviewed.

Ammonia

Better known as ammonium hydroxide, aqua ammonia, spirits of hartshorn. Its chemical formula is NH_4OH. A colorless solution of ammonia in water, it is readily available in different concentrations, but for the present purpose the 28 per cent (specific gravity 0.897) is commonly used, and readily available.

Ammonium Chloride

Also known as sal ammoniac and ammonium muriate. Chemical formula, NH_4Cl. It is a white or grayish lump, crystal or powder, with a specific gravity of 1.520; readily soluble in water.

Brighteners

The nickel film deposited from an acid bath is dull and tends to be rougher than the deposit from the alkaline solution. By adding "brighteners" to the solution, semi-bright deposits may be obtained according to Brenner and Riddell. Suitable materials are the brighteners obtainable from the Harshaw Chemical Co. The recommended compound is type XXX44, of which use 6 cc., and 0.3 cc. of type XXX20 per liter of nickel solution.

Citric Acid

Colorless crystals or white powder, odorless. Chemical formula is $C_3H_4(OH)(COOH)_3H_2O$; specific gravity, 1.542; readily soluble in water.

Cobalt Acetate

Reddish-violet deliquescent crystals; specific gravity is 1.7043; chemical formula, $Co(C_2H_3O_2) + 4H_2O$; readily water soluble.

Cobalt Chloride

Commercially it is available as a fine pinkish crystalline powder. Chemical formula is $CoCl_2.6H_2O$.

Cobalt Sulphate

See cobalt chloride. Chemical formula is $CoSO_4.7H_2O$.

Nickel Borate

This chemical does not exist as a true compound, it is possible that nickel fluoborate might be used in the formulation.

Nickel Chloride

Green deliquescent crystals. Chemical formula is $NiCl_2.6H_2O$; readily water soluble.

Nickel Formate

Not readily available; may be termed special.

Nickel Sulphate

Green crystals; chemical formula is $NiSO_4.7H_2O$.

Pyrogallol

Originally used as a reducing agent in photography; sometimes called pyrogallic acid; chemical formula is $C_6H_3(OH)_3$.

Rochelle Salts

Also used in mirror making as a reducing agent. Chemically it is termed sodium-potassium tartrate; formula is $NaKC_4H_4.4H_2O$.

Silver Nitrate

Also used in mirror making; readily water soluble. Chemical formula is $AgNO_3$.

Sodium Acetate

Colorless efflorescent, transparent crystals; specific gravity is 1.4; chemical formula, $NaC_2H_3O_2.3H_2O$; readily soluble in water.

Sodium Bisulphite

White crystalline or amorphous powder, with the chemical formula, $Na_2S_2O_5$, molecular weight, 190.12; readily soluble in water.

Sodium Citrate

Colorless crystals; chemical formula, $Na_3C_6H_5O_7.2H_2O$; specific gravity, 1.857; readily soluble in water.

Sodium Hyrosulphite

Chemical formula is $Na_2S_2O_4.2H_2O$. It is a colorless amorphous crystal, readily soluble in water.

Sodium Hydroxyacetate

Very readily formed by adding sufficient sodium hydroxide to neutralize hydroxyacetic acid in the form of a 70 per cent solution. For the present purpose, the salt is not isolated. Chemical formula is $NaC_2H_2O_2$.

Sodium Hypophosphite

A free flowing white odorless crystal; molecular weight, 106.01; chemical formula, $NaH_2PO_2.H_2O$. It is a neutral salt whose ion is strong, though a slow-acting reducing agent. The chemistry of the compound is discussed by Brenner and Riddell; Latimore; and Mellor.

(*Continued on page* 35)

Russian Translations of Interest to the Glass Industry

Tests on Ziralite Refractories

M. I. Koz'min, A. G. Minakov and G. M. Koval'chuk report on these tests in *Steklo i Keramika (Glass and Ceramics) 15*, No. 4, p. 11-16 (1958).

Three kinds of Ziralite have been used. Their chemical and mineralogical compositions, and the rate of their corrosion by molten glass (a borosilicate glass ZS-5 for Ziralite II and window glass for Ziralites I and III) are listed in Table I. All Ziralite blocks (produced by a pilot plant) contained fissures some of which were as deep as 60 mm.

Blocks No. 7 and 15 had composition I; blocks No. 29, 30, 32, 33, and 34 had composition II; they and block 37 (of composition III) had dimensions 600 x 300 x 250 mm., and blocks 48 and 49 (of composition III) were 600 x 400 x 250 mm.

Table I

	Ziralite		
Chemical composition, %	I	II	III
Al_2O_3	54	52	50
SiO_2	16	16	18
ZrO_2	30	32	32
Mineralogical composition, %			
Corundum	10	up to 20	some crystals
Baddeleite	30	about 30	about 30
Mullite	50	about 40	up to 60
		Corrosion by molten glass mm./day	
below glass level	0.56	1.44	0.62
at glass level	0.65	1.17	0.82

These blocks were tested in a glass furnace of continuous action (No. 7, 15, 29, 34, 48 and 49) and in a glass furnace working intermittently (the other blocks).

The continuous furnace produced about 31 metric tons of glass daily, the area of its melting end was 80 square meters, the area of the fining end 30.9 square meters, the depth of the tank 1.5 meter, and there were 4 pairs of burners. Two screens separate the flame spaces of the two ends. The furnace was heated with purified and cooled producer gas obtained by gasification of anthracite.

The glass contained SiO_2 75.10, Al_2O_3 0.37, Fe_2O_3 0.06, CaO 8.35, MgO 0.3, Na_2O 15.12, and SO_3 0.7 per cent. A mixture of As_2O_3 and Sb_2O_3 was introduced to avoid discoloration. The ratio of soda ash to sulfate in the batch was 19:1. For each 7 parts batch 1 part cullet was charged. The maximum furnace temperature was $1465 \pm 5°C$.

The position of the Ziralite blocks in the furnace is indicated in Fig. 1 and Fig. 2. Fig. 1 is a plan of the glass tank, showing the parts of the walls made of Ziralite, of a "ceramic refractory containing a high percentage of alumina" (High –Al in the figure), and of quartz. All furnace dimensions are in mm. The upper part of the graph indicates the temperature distribution along the furnace (in °C).

TABLE II

REFRACTORY THICKNESS, mm.

	High-alumina			Ziralite						High-alumina		
	No. 1	No. 2	No. 3	No. 34	No. 15	No. 7	No. 48	No. 49	No. 29	4	5	6
At glass surface	125	104	115	166	220	213	165	200	138	130	96	103
200 mm. under the block top	145	150	160	212	217	215	205	210	200	150	104	154
400 mm. under the block top	183	187	190	227	209	216	215	190	215	178	170	195
At block bottom	152	140	144	165	151	152	145	163	115	146	136	125
Mean	151	145	152	192	199	199	182	191	167	151	128	166

TABLE III

REFRACTORY THICKNESS, mm.

	Ziralite				Quartz	
	No. 37	No. 33	No. 30	No. 32	No. 1	No. 2
At glass level	140	90	30	121	195	198
200 mm. below the block	145	126	42	115	197	201
400 mm. below the block	190	155	105	185	196	196
At block bottom	200	160	110	160	200	199
Mean	177	133	72	145	197	199

Fig. 2 presents a view of the inside wall of the furnace. "Zr" with a number underneath indicates ziralite blocks numbered as above ГВ were "high-alumina" blocks, and Сш were chamotte blocks; they also were numbered as above, and the numbers are used in Table II.

The maximum furnace temperature was approximately 170°C after 24 hours, and about 300°C, 480°C, 600°C, 850°C, 1070°C, and 1465°C, respectively, after 2, 3, 4, 5, 6 and 7 days. The filling of the furnace with glass took 8 days. Air cooling was introduced two months after the start of operations. The furnace was cooled for repairs 321 days after this start.

The ziralite blocks were less corroded than the surrounding refractories and visibly stuck out. Quantitative results are collected in Table II which shows the thickness of the blocks after the campaign; the initial thickness was 250 mm. in all instances.

Table II demonstrates the superiority of the ziralite blocks; composition I had the best resistance, and composition II the poorest.

In Fig. 3, data for ziralite are plotted together with earlier data obtained in the same glass plant for the same glass composition but with different refractories. The ordinate of the graph means the thickness (in millimeters) of the layer removed during the time plotted along the abscissa (months). Field 1 is for quartz blocks, field 2 is for kaolin, 3 for mullite and "high-alumina" blocks, and 4 for ziralite.

The type of corrosion of ziralite was different from that observed for "high-alumina" blocks. This is clearly seen in Fig. 4 which is a photograph of the refractories (with their code numbers) after the campaign. Fragments of considerable size fell out of the ziralite blocks and the remaining surface was covered with fine fissures.

Along the seams between the ziralite blocks these were destroyed to the depth of 80 mm. The attacked surface had a pinkish cream color. Four zones could be seen with unaided eye in the remaining block. The first was white, opaque, and 2-4 mm. thick; the second was brown and up to 12 mm. thick; the third, dark-brown and 10-15 mm. thick, and the fourth (i.e., the rest) had the initial ash-grey color. Block No. 49 had vertical voids up to 80 mm. deep, bridged by material having the texture of the main body of the block. In some blocks, the material next to the voids had a coarse crystalline structure, and loose crystals filled separate voids.

The glass produced by the furnace had a consistently high quality with an insignificant amount of striae and other defects. Its transparency exceeded 90 per cent per centimeter. Since the area occupied by the ziralite blocks was relatively small, their effect on the quality of the glass could not be ascertained.

The main conclusion of the above test is that a combination of ziralite in the high-temperature zone with fused quartz in the low-temperature zone presumably will extend the working time of a furnace and improve the glass quality.

Another test was conducted in a small furnace of periodic action. Ziralite blocks No. 30, 32, 33, and 37 were used. The glass composition was SiO_2 80.6 per cent; B_2O_3 12; Na_2O 4.9; Al_2O_3 1.5; MgO 0.5; and As_2O_3 0.5 per cent. Figure 5 indicates the position of

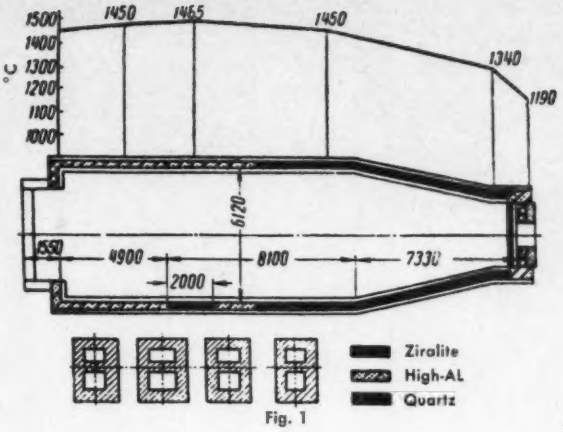


Fig. 1

the ziralite blocks in the furnace; the rest of the walls was constructed with quartz blocks. The area of the tank was 5 square meters, its depth 0.6 meter, and its capacity 6.4 tons of glass. In each cycle, 4.6 metric tons

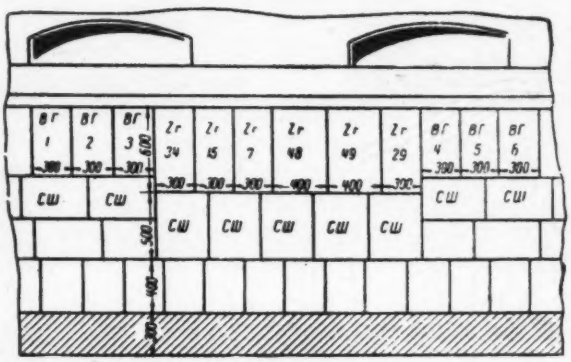


Fig. 2

of glass were produced, and the glass level in the tank descended by 400 mm.

The glass making lasted 36 hours. The maximum fining temperature was 1610°C. Then cooling to 1460°C

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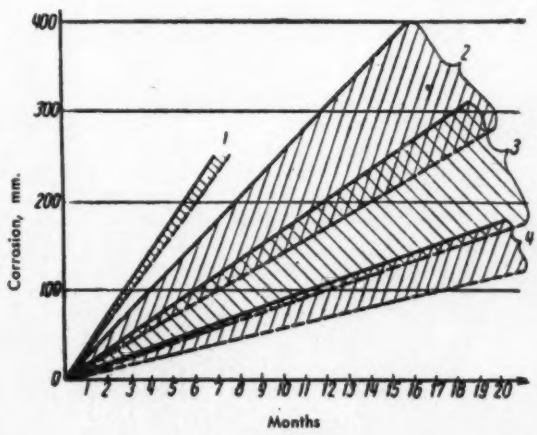
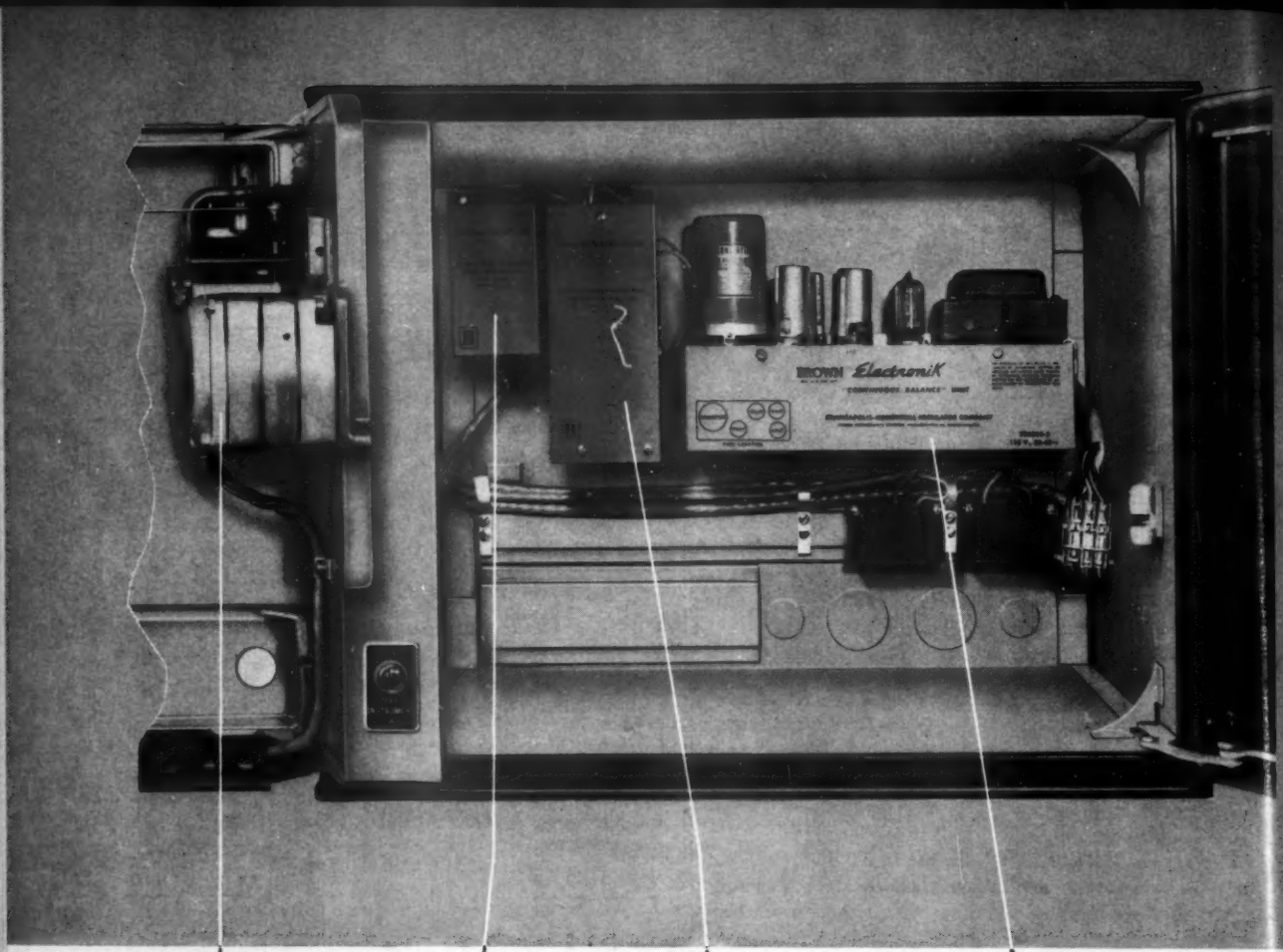
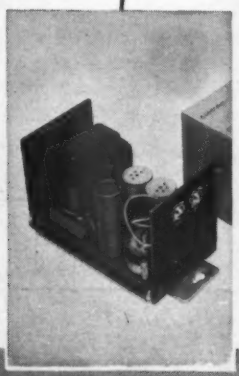


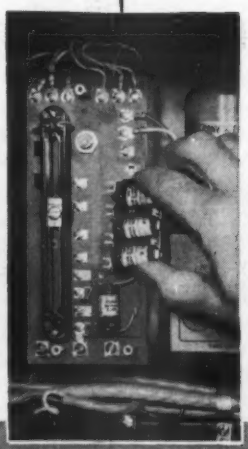
Fig. 3



Servo Motor has sectional housing, leakproof oil wick, printed circuits for simplified servicing. Any major part can be replaced in 2 minutes.



Constant Voltage Module—Uses Zener diodes and an ambient temperature compensator to replace standardizing mechanism.



Measuring Circuit Module—Contains easily-changed range spool panels and vernier adjustment. Range is changed simply by replacing screw-clip panels of fixed resistors.

Amplifier Module—Quick-connect design permits fast, easy removal for servicing and replacement. Circle shows quick connect plug.

THESE FOUR NEW FEATURES ARE STANDARD WITH ALL *ElectroniK* POTENTIOMETERS

New modular design...

makes *ElectroniK* potentiometers easier to use and maintain

Now, four great new features add new operating and servicing ease to all *ElectroniK* circular and strip chart potentiometers.

- **New servo and chart drive motors are sectionalized so that any major part can be replaced in two minutes.**
- **A new constant voltage unit replaces batteries, standard cells and standardizing mechanisms.**
- **A new measuring circuit, with quick-change range spools, simplifies range changing and reduces stray pickup.**
- **A quick-connect feature lets you remove the amplifier for service and replace it quickly.**

Now, modular design is combined with the traditional precision of *ElectroniK* potentiometers, to give you a greater value than ever in accurate, dependable measurement and control.

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75th YEAR — PIONEERING THE FUTURE

Honeywell

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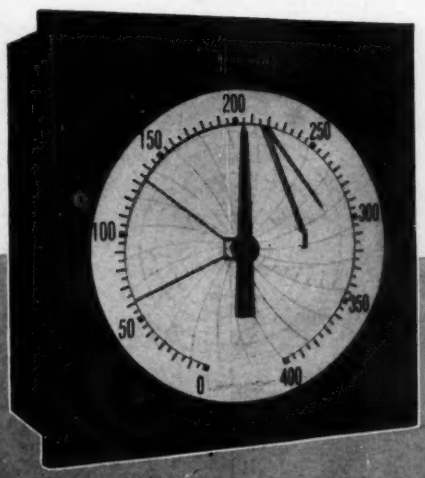
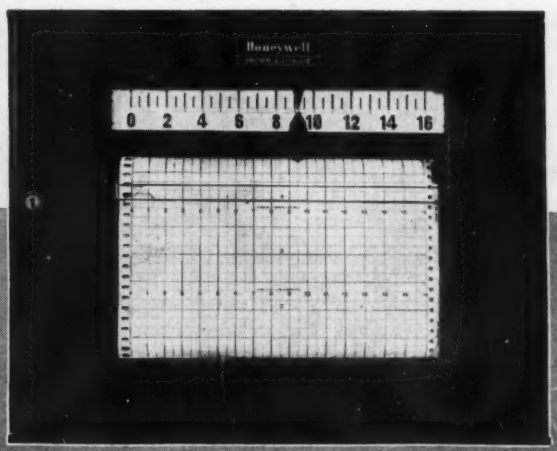




NEWS in The Glass Industry

F. N. Dundas

N. W. Meldrum

Promotions at Dominion Glass

F. N. Dundas has been named president and director, and N. W. Meldrum, vice president and general manager, of the Dominion Glass Company Ltd., in Montreal, Canada.

Kaiser Appoints Harrison and Gaebe

L. A. Harrison and Philip A. Gaebe have been appointed general sales manager and assistant general sales manager, respectively, of the eastern division of Kaiser Refractories & Chemicals.

Mr. Harrison was associated with Mexico Refractories Company and his appointment follows the recent merger with the Kaiser organization.

Mineral Mining Expanded

Metal & Thermit Corporation is expanding its mineral mining operations at Hanover County, Va., to develop substantial quantities of aplite present in the ore body. The mineral is one of a group of minerals used by the glass industry as a source of alumina in the production of colored and flint container and window glasses.

The mineral will be produced in two grades, and Commercial quantities are expected to be ready by June, 1960.

Doner Honored by Industrial Designers

H. Creston Doner, director of design and color at Libbey-Owens-Ford Glass Co., was named president and fellow for life during the closing session of the 21st annual conference of the trustees of the Industrial Designer's Institute. Mr. Doner was bestowed the life membership of "fellow" for rendering distinguished service to the designing profession and the Institute. The honor was proposed by the executive committee of the Detroit chapter of which Mr. Doner is a member.

Four Transferred at Diamond Alkali Co.

Z. A. Stanfield, technical superintendent at Diamond Alkali Company's Belle, West Va., plant will be transferred to the organization's Greens Bayou operations, Houston, Tex., in the same capacity. This is a newly created position at the plant. D. R. Pulver, senior engineer of the company's technical staff in Cleveland, O. will succeed Mr. Stanfield at the Belle plant.

V. C. Cayton, process engineer at Diamond's Deer Park, Tex., plant will succeed Mr. Pulver on the technical staff, and G. E. Taylor has been appointed to Mr. Cayton's vacated post.

Shaw Promoted at Corning

Dr. Morton R. Shaw has been promoted to manager of Product development for the electronic components department of Corning Glass Works. He has been supervisor of the department since last April.

New Trademark for O. Hommel

The O. Hommel Company has adopted a new trademark to illustrate the firm's role in the ceramic industry's future development.

The trademark is the ancient alchemist symbol for vitrum, the Latin word for glass, and consists of a *V* interlocked with an inverted *V*.

The company adopted this trademark because it believes the basic ceramics manufacturer has changed from a mere supplier to a research and production associate.

Cook Appointed at Selas

Eugene A. Cook, Jr. has been appointed chief engineer for Selas Corporation of America. He will direct the designing and engineering of heat processing equipment for the glass and ceramic industries.

H. Creston Doner

Eugene A. Cook, Jr.

Owens-Corning Receives Award

Owens-Corning Fiberglas Corporation has won the *Financial World's* award for the best annual report in the glass products classification. In the last eight years the company has won the award six times.

O-I To Expand Venezuelan Plant

Owens-Illinois Glass Company will double the capacity of its Valencia, Venezuela, glass container plant in order to keep up with the increased demand for glass containers in that area. Floor space of the year-old plant will be expanded by 100,000 square feet in order to accommodate an additional glass-melting furnace and three automatic bottle-making machines. The quality and specifications laboratory, batch handling equipment and in-factory offices areas will also be enlarged.

O'Meara Harbison-Carborundum President

Eugene L. O'Meara, Jr., formerly general purchasing agent of Harbison-Walker Refractories Company has been named president and member of the board of the newly organized refractories firm, Harbison-Carborundum Corporation.

The new firm is owned on a 50-50 basis by Harbison-Walker and The Carborundum Company and each of the parent firms has named three executives for the Harbison-Carborundum Corporation board of directors.

Executives from Harbison-Walker are: Mr. O'Meara; Edward T. Hile, vice president in charge of manufacturing, and Lawrence E. Mock vice president and treasurer. Carborundum executives are: Boyd M. Johnson, vice president and general manager of the refractories division at Perth Amboy, N.J.; Arthur A. Turner, sales manager of the refractories division and William H. Wendel, member of the board and executive vice president.

The new corporation's headquarters are located at Carborundum's fused refractories plant at Falconer, N.Y., which will become part of the new firm.

Board of directors for the newly formed Harbison-Carborundum Corp. Bottom row, left to right: Eugene L. O'Meara, Jr., member of the board and president of the new corporation; Edward T. Hile and Lawrence E. Mock, of Harbison-Walker. Top row, left to right: Boyd M. Johnson; Arthur A. Turner, and William H. Wendel, of Carborundum Co.

Roy W. Yunker

Yunker Appointed at PPG

Roy W. Yunker has been appointed to the newly-created position of manager of process and development for the glass division engineering department of Pittsburgh Plate Glass Company.

Mr. Yunker joined the company in 1947 and served as plant engineer at the Cumberland, Md., operations before his appointment.

LOF 25 Year Awards

Libbey-Owens-Ford Glass Company honored three officers and 119 employees from the company's Toledo, O., area for 25 years of service at a dinner given in the Commodore Perry Hotel, Toledo, O., December 8.

The officers, elected vice presidents earlier last year, were: Harold M. Alexander, vice president, technical services; James M. Ashley, vice president, public relations, and Horace G. Orser, vice president, special products, production.

John D. Biggers was chairman of the dinner program. President George P. MacNichol Jr., the principal speaker, noted some important changes that have taken place since 1934, the year the award winners became associated with the firm.

"In those days, not only was the general business level low, but our industry's participation in both automotive and construction markets was small. . . . Windshields and windows were small by comparison with today's standards, and flat. A Chevrolet sedan had only 5.9 square feet of flat laminated glass and 13.7 square feet of flat plate glass in 1934, compared with 15.8 square feet of curved laminated glass, 11.3 square feet of flat laminated glass, one square foot of flat tempered glass, and 10 square feet of curved tempered glass in the 1959 model. . . . Much more work is involved not only in making the greatly increased footage per car but in the more complicated shapes we are called on today to produce.

"Our share in the construction dollar was small, too. The relatively few homes which were built in 1934 were glazed with small bracket window glass. . . . There were no picture windows, sliding glass doors, or window walls. Almost no glazing plate glass was used in homes. . . . What office buildings and schools were built had relatively small window openings in heavy masonry walls."

R. H. Barnard, Jr.

Robert L. Hull

H. M. Heyn

E. P. Heiles

J-M Names Barnard and Hull

R. H. Barnard, Jr., and Robert L. Hull have been named managers of plants eight and nine, respectively, at the Defiance, O., operations of Johns-Manville Fiber Glass, Inc.

Mr. Barnard was previously manager of plant number three. He has been with the company and its predecessor firms, Libbey-Owens-Ford Glass Fibers and Glass Fibers, Inc., since 1951.

Mr. Hull was a department head at plant number three prior to his appointment. He has served as supervisor of the insulation department and assistant department head since he joined the company and its predecessor firms in 1950.

Denson Appointed at Knox

Kenneth E. Denson has been appointed a sales representative in the St. Louis area for Knox Glass, Inc. He has been with the company since 1952 serving in sales activities in the South and Southwest.

Promotion at Babcock & Wilcox

Robert A. Barr has been elected vice president in charge of refractories at the Babcock & Wilcox Company. He was formerly general manager of the division. The company manufactures boilers, nuclear heat exchangers and other similar equipment.

McNerney Named at O-I

J. F. McNerney has been named manager of the Milwaukee branch of the Owens-Illinois Glass Company's glass container division. He has been with the firm since 1934 and succeeds George Levis who is retiring after 26 years with the company.

Plant Maintenance & Engineering Conference

The Plant Maintenance and Engineering Conference will hold its 11th annual meeting January 25-27, in Convention Hall, Philadelphia, Pa., concurrent with the Plant Maintenance and Engineering Show.

The new topics to be added to the 1960 program are Research and Development Techniques in Maintenance, Plant Engineering in Planning to Combat Disaster by Flood and Tornado and What the Plant Engineer Should Know About Building Design and Construction.

Executive Appointments

Henry M. Heyn and Eugene P. Heiles have been appointed vice presidents of the Midland-Ross Corporation, which recently acquired the Surface Combustion Corp.

Mr. Heyn is now head of Surface Combustion, a division of the corporation which includes Janitrol Aircraft, Janitrol Heating and Air Conditioning. Two subsidiaries, Webster Engineering and Surface Industrial Furnaces, Ltd., will also be under his supervision.

Mr. Heiles served as vice president and controller of Surface Combustion Corporation prior to his appointment and will assume the duties of general manager of Surface's Toledo, O., operations.

Harbison-Walker Promotes Two

H. A. Bednarski and K. E. Hansen have been promoted assistant manager of basic sales, hearth materials, and assistant manager of basic sales, respectively, at Harbison-Walker Refractories Company.

Wood Retires From Hayward

James Wood, sales department head since 1949, has resigned as vice president of Hayward Scientific Glass Corporation.

Falconer Completes New Building

Falconer Plate Glass Corporation has completed construction of their new 20,742 square foot building which will house the company's office and provide additional warehouse facilities. The building, faced with curtain walls in the office section, is located on property adjacent to the present mirror plant. The new facilities are expected to provide better production operation and automation.

Glass for Swedish Building

Irregular patterns of black and transparent glass alternating with each other in aluminum frames—and placed over a skeleton of concrete—form the exterior walls of the $5,500,000 National School of Arts, Crafts and Design in Stockholm, Sweden.

Defrayed by government appropriations, the school accommodates 1,000 students in departments of instruction that include glass and ceramics.

Glass Drainline System

A glass drainline system for the disposal of chemical wastes has been developed by Corning Glass Works. The lightweight glass pipe has one-piece couplings which are said to permit quick, permanent compression joints. The drainlines are guaranteed by Corning to resist breakdown by corrosion or joint leakage for the lifetime of the building in which it is installed.

Designed for vertical or horizontal mounting the pipes can be buried in the ground and only massive quantities of hydrofluoric acid and hot alkalies are said to measurably affect the hard, low expansion borosilicate glass.

The coupling has a liner of Teflon 100-X, a rubber sleeve and a stainless steel shell. The glass pipes are stabbed into the coupling which is tightened by one nut. Thirty different glass fittings are offered for the drainline system. The pipe is available in lengths of five and ten feet with diameters ranging from one and one half to six inches.

Weiss Manager at General Electric

Herman L. Weiss has been appointed general manager of General Electric Company's lamp division. He joined the division at its Pitney Glass Works in 1939.

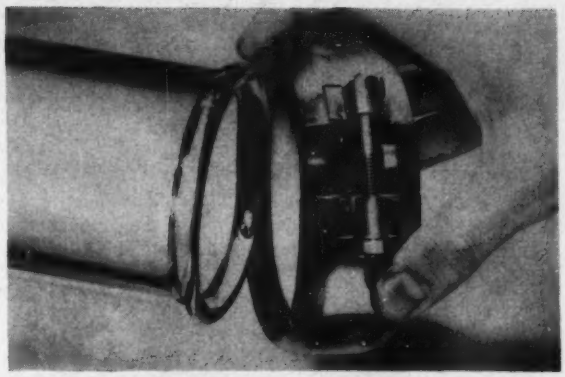
J-M To Double Size of Corona Plant

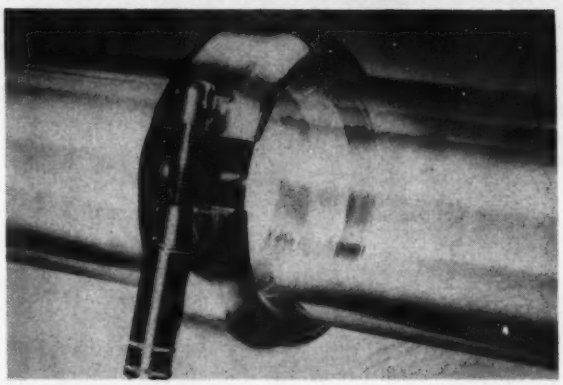
The Johns-Manville Fiber Glass division plant, Corona, Calif., will be doubled in size by the middle of this year.

A total of 91,200 square feet will be added to the existing 105,000-square-foot building. Raw materials, in-process and finished goods will be stored in 84,000 square feet of the new space thus allowing room in the present building for installation of additional manufacturing and fabricating machinery. An extension covering 7,200 square feet will house raw material mixing and utility services.

The Corona plant produces fiber glass insulation materials for houses, mobile homes, refrigerated truck-trailers, railroad cars, heating and air conditioning equipment, ducts and piping. The operation also includes fabrication of high-temperature insulation components for the aircraft and allied industries.

Dotted lines indicate new additions to the J-M Fiber Glass Plant in Corona, Calif. Area at the left will comprise 84,000 sq. feet and the area at the right will comprise 7,200 sq. feet.





Glass piping drainline system by Corning Glass Works designed to make a quick, permanent compression joint. The pipe ends are stabbed into the one-piece coupling and the joint is sealed by twisting one bolt.

PPG Establishes New Fabrics Department

Albert W. Metzger has been appointed merchandising manager of Pittsburgh Plate Glass Company's newly established decorative fabrics merchandising department. The company's decision to establish the new department was founded on the increasing demand for fiber glass textile yarn.

Miller, Eastern Sales Mgr., Owens-Illinois

Robert F. Miller, manager of the New York branch of the glass container division of Owens-Illinois, has been appointed eastern regional sales manager. He has been with the company since 1941.

Lambertson Promoted at Carborundum

Dr. Wingate A. Lambertson. formerly assistant manager, has been promoted manager of the engineering branch of the Carborundum Company's research and development division.

A specialist in nuclear ceramics and high temperature research, he was associated with the Argonne National Laboratory as a research associate from 1949 to 1953 working in basic research on atomic reactors.

Erratum

On page 632, November issue, the names under the photographs of Robert A. Sanders and T. A. Rohlfsen were reversed. The photograph on the left is T. A. Rohlfsen, and on the right, Robert A. Sanders.

Richard B. Tucker

Richard B. Tucker, former executive vice president and member of the board of Pittsburgh Plate Glass Company, died November 26, 1959 at his home in Virginia Beach, Va.

Mr. Tucker retired from the company in 1955 after 50 years in the flat glass industry. He began his career in 1906 as manager of the John D.

Richard B. Tucker

Gordan Company in Camaguey, Cuba. In 1929 he became manager of glass sales for Pittsburgh Plate Glass. He also served as a member on the boards of Columbia-Southern Chemical Corporation, Duplate Canada, Ltd., and Canadian Pittsburgh Industries, Ltd.

Samuel J. Singer

Samuel J. Singer, founder and partner of Specialty Products Company died November 4, at Mount Sinai Hospital in New York City.

Thomas W. Bassett

Thomas W. Bassett, president and general manager, of Dominion Glass Company Ltd., died recently after 59 years in the glass industry.

In 1910 Mr. Bassett joined the Diamond Flint Glass Company in Montreal, Canada, which later became Dominion Glass Company. He became plant manager of the Wallaceburg, Ontario, works in 1925 and general manager of the company in 1937. He was elected vice president in 1939 and president in 1955.

New Firm Established

United Electric Controls Company, Watertown, Mass., has established a manufacturing facility in Dorval, Quebec, Canada under the name of United Electric Controls (Canada) Ltd. It will produce temperature, pressure and vacuum controls.

Hazel-Atlas Appointments

Jack L. Hendrickson and Harold J. Stullenburger have been appointed product sales manager and assistant to the general manager of sales, respectively, at the Hazel-Atlas Glass Division of Continental Can Company. Mr. Hendrickson replaces J. C. Neuhart who is retiring after having been with the company since 1918.

Boeschenstein Speaks to Housing Industry

Harold Boeschenstein, president of Owens-Corning Fiberglas Corporation, told members of the housing industry that they must borrow techniques from the auto industry to realize the market opportunity coming up in the sixties.

He spoke in a closed-circuit telecast from the National Association of Home Builders' Housing Center to home builders, suppliers, FHA officials, realtors and home finance authorities in 30 cities throughout the U.S. Mr. Boeschenstein said the techniques of creating consumer desire for "new models," planning effective handling of "trade-ins," and offering easier financing for buyers could prove effective for the housing industry which is on the threshold of its greatest market opportunity.

FINANCIAL DATA: 9-MONTH PERIOD 195

American Potash & Chemical Corp.

	1959	1958
Net earnings	$ 3,805,555	$ 3,155,39
Net sales	41,242,331	35,619,68

American-Saint Gobain Corp.

	1959	1958
Net earnings	$ 435,507	$ 346,250 (net loss)
Net sales	24,411,228	17,149,820

Corning Glass Works

	1959	1958
Net earnings	$ 17,944,084	$ 11,525,270
Net sales	147,717,908	117,531,383

General Refractories Co.

	1959	1958
Net earnings	$ 2,715,177.93	$ 2,214,559.61
Net sales	41,749,562.49	34,571,362.02

Knox Glass, Inc.

	1959	1958
Net Sales	$29,653,351	$26,571,250

Libbey-Owens-Ford Glass Co.

	1959	1958
Net earnings	$42,156,448	$11,091,809

Owens-Illinois Glass Co.

	1959	1958
Net earnings	$ 32,244,447	$ 27,435,010
Net sales	426,731,588	379,711,542

Pittsburgh Plate Glass Co.

	1959	1958
Net earnings	$ 34,064,967	$ 24,810,021
Net sales	446,248,355	400,604,564

Thatcher Glass Mfg. Co., Inc.

	1959	1958
Net earnings	$ 2,023,118	$ 1,702,979
Net sales	39,652,673	32,109,163

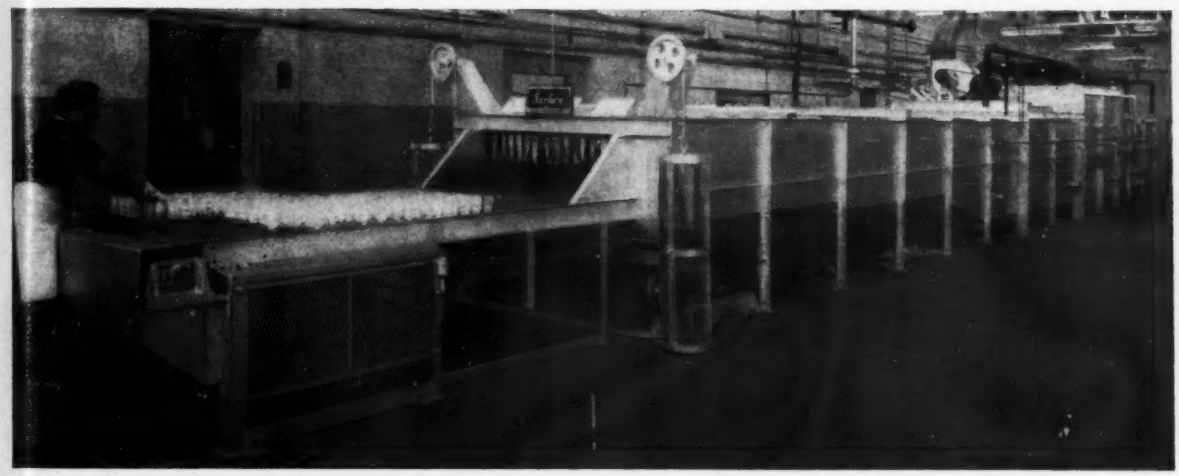
a "useful life" can cost you money

Depreciation policies based on the useful physical life of equipment have lulled many companies into dangerous complacency. By ignoring inflation and technological obsolescence, they pay dividends and taxes on profits which don't really exist.

Inevitably, they discover that their depreciation reserves are inadequate to replace worn out or obsolete equipment.

However, aggressive managements have found two alternatives to that dilemma. First, they prove to the Government that their depreciation rates should be based on the economic—not the physical—life of their equipment.

Second, they purchase equipment which will recoup their investment within its economic lifetime. This is the factor which prompts many companies to specify Surface Combustion lehrs, kilns, and ovens.



This radiant tube decorating lehr is recouping its owner's investment.

Surface Combustion · 2378 Dorr St., Toledo 1, O.

A Division of Midland-Ross Corporation · *In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario*

wherever heat is used in industry

Surface

INVENTIONS AND INVENTORS

Feeding and Forming

Method of glass manufacture. Patent No. 2,886,491. Filed January 12, 1953. Issued May 12, 1959. No sheets of drawings; none reproduced. By Joseph Jerger, Jr. and Walter A. Fraser.

The invention relates to a method and means for refining materials, such as certain glasses, having substantially a single boiling point or a relatively narrow boiling range.

The invention contemplates improved methods and means for the refinement of a material having essentially a single boiling point or boiling range and thus capable of refinement by distillation. The method and apparatus lend themselves particularly to the refinement of materials which are conductive, at least in their melted state, as for example, certain glasses and metals. If the material is conductive essentially only when melted, then the method of the invention may be said to comprise, first, the melting of the material, and then the passage of an electric current through a volume of the melted material, the current being of a magnitude to induce boiling, so that the refined product may be available through distillation. A heated receiver may hold the distillation products treated in the liquid state, until ready for annealing or other processing into the solid state.

Materials such as arsenic trisulfide, selenide and telluride glasses characterized by a single boiling range are particularly adaptable to the process.

There were 6 claims and 11 references cited in this patent.

Apparatus for feeding molten glass. Patent No. 2,883,798. Filed March 8, 1954. Issued April 28, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Corning Fiberglas Corporation by Robert G. Russell.

The invention particularly relates to apparatus for feeding molten glass in the form of minute streams which are attenuated to form continuous glass fibers. This type of glass feeder is referred to as a bushing and is made in the form of a trough shaped receptacle in which is contained a body of molten glass. The bottom of the trough shaped receptacle is perforated to form a plurality of spaced orifices of the same diameter through which the individual streams flow.

The streams are attenuated into fibers by being mechanically grasped on a rotary spool type package and pulled linearly at a speed, say, 10,000 feet per minute.

The apparatus of the invention involves the concepts of homogenizing a mass of glass both as to temperature and constituents by recirculation, the introduction of new raw material into the system, preferably at a point in the recirculation where the mass being recirculated is hottest and the divergence of a portion of the glass being recirculated from the recirculation path to a path leading to the fiber forming tip section. Positive acting means are present at several points throughout the recirculation and diversion system to provide a long tortous path for the glass and thus to expose it to a large heating area for making the temperature uniform and for preventing impurities from passing through to the fiber forming portions of the device.

There were 13 claims and the following references cited in this patent.

United States Patents

1,710,789, Soubier, Apr. 30, 1929; 1,959,417, Flexon, May 22, 1934; 2,331,946, Pazsiczky et al., Oct. 19, 1943; 2,407,295, Simison et al., Sept. 10, 1946; 2,411,031, Dayrup, Nov. 12, 1946; 2,515,478, Tooley et al., July 18, 1950; 2,716,023, Cleveland, Aug. 23, 1955.

Foreign Patent

711,976, France, Sept. 22, 1931; 725,225, Great Britain, Mar. 2, 1955.

Glass Compositions

Glass composition. Patent No. 2,883,293. Filed June 11, 1957. Issued April 21, 1959. No sheets of drawings; none reproduced. Assigned to Servo Corporation of America by Joseph Jerger, Jr. and John E. McKenna.

This invention relates to glasses produced from ternary mixtures of the elements arsenic, selenium and tellurium, forming an optical infra-red transmitting glass.

Examples of good glasses are as follows:

Designation	Percent AS	Percent Se	Percent Te
x	10	80	10
a	20	70	10
b	30	60	10
c	45	45	10
d	50	40	10
e	10	70	20
f	20	60	20
g	40	35	25
h	10	60	30
i	20	50	30
j	25	40	35
k	40	25	35
l	30	30	40

By adding tellurium to the arsenic-selenium compositions, an improved combination of transmission properties is assured and makes available a whole new group of compositions having a wider range of selenium content

as well as extending the range of the other elements. Thus, according to the diagram, selenium is made to range by weight from about 23 per cent to 95 per cent, tellurium from about 2 per cent to 42 percent, and arsenic from about 2 per cent and more preferably from about 8 per cent to 52 per cent.

There were three claims and the following references cited in this patent.

THE GLASS INDUSTRY, September 1935, page 285. Pelabon; *Ann. Chem. Phys., Chem. Abst.* 17, 526-566, 1910, vol. 4, pages 10-11, 1910.

RUSSIAN TRANSLATIONS

(*Continued from page* 25)

and working for 12 hours followed. The temperature rise to 1600°C took 5 days. The walls were not cooled during the campaign. The furnace was stopped for cold repair after 15 months. Table III shows the degree of corrosion observed. The initial thickness again was 250 mm. in all instances.

It is seen that borosilicate glass corroded quartz less seriously than ziralite and that composition III was more resistant than composition II.

The profiles of the blocks after the campaign are outlined in Fig. 6. All dimensions are in millimeters. No. 1 and No. 2 are quartz, and the upper row refers to ziralite. The irregular profile of the ziralite blocks was caused by the initial fissures which gave rise to flaking off. Flaking off was intensified by the frequent temperature variations in the furnace (within 200°C) associated with the periodic régime of the tank. This effect was particularly marked for ziralite No. 33 which was placed under the exit door and, consequently, was swept by the cold outside air every time the door was opened.

Under each test block, irregular fragments of the block measuring up to 50 mm. were visible on the furnace floor. When it was attempted to remove the blocks from the furnace, they disintegrated. The surfaces of the broken block had its initial ash-grey color and the initial fine and dense texture.

The conclusion from the second test is that ziralite is less suitable for borosilicate glasses than is fused quartz.

Fig. 4

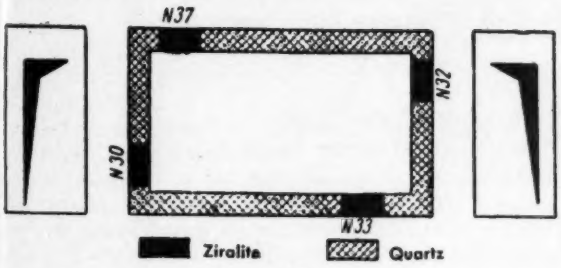


Fig. 5

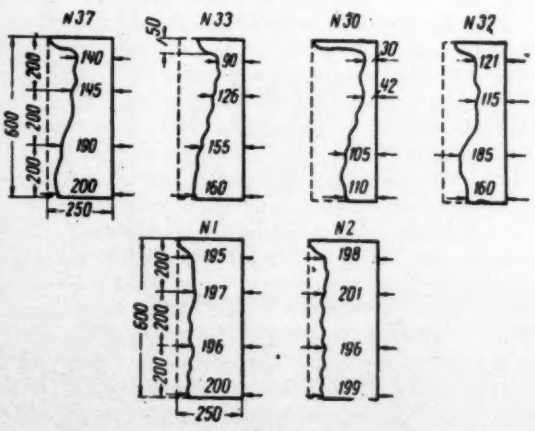


Fig. 6

Polishing Discs of Butyl Methacrylate Polymer

V. S. Peselov and E. S. Nifontova report in *Steklo i Keramika (Glass and Ceramics) 15*, No. 4, p. 5 (1958), on their experiences with polishing discs made of a polymer butyl methacrylate containing 8.8-9.7 per cent dibutyl phthalate.

NICKEL AND COBALT FILMS

(*Continued from page* 23)

Wetting Agents

Up to 10 per cent by weight of any of the wetting agents commonly used has been advocated to facilitate deposition and adherence of the nickel or cobalt film.

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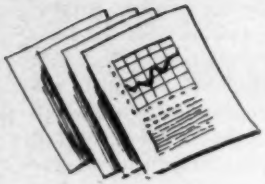
(*Continued on page* 46)



RESEARCH DIGEST

The Sénarmont Method for Measuring Stresses in Glass

● H. Rawson in the June, 1958, issue of the *Journal of the Society of Glass Technology* points out some of the advantages of the so-called Sénarmont method of photoelastic stress measurement when applied to the measurement of stresses in glass and glass-to-metal seals. This is a method which, in the author's (Rawson) opinion, is not as widely known or as widely used in the glass industry as it deserves to be. It simplifies the optical system required in the stress-optical bench, which can be set up very easily and cheaply, and it could probably be used as the basis of a measuring strain viewer for use in the factory.

The most widely used methods for measuring stresses in glass make use of a compensator, usually of either the Babinet or Berek type, which introduces into the light beam an effect equal and opposite to that introduced by the stresses in the specimen. These instruments are moderately expensive and their use calls for an optical system which has to be lined up rather carefully, and the design of which is determined to a large extent by the compensator. The Sénarmont method does not impose the same restrictions on the design of the optical system, which can as a result be considerably simpler.

The technique was first described many years ago by de Sénarmont (1840), but a more readily available description of the technique is that given by Jessop (1953). Jessop gives the theory of the method and analyses some of the possible errors. The theory is also given in a more general form by Goranson & Adams (1933) who were the first workers, to the author's knowledge, to use the method for measuring stresses in glass. By using a half shadow plate as an additional refinement, they were able to measure retardations with an accuracy of ± 0.05 mμ. This degree of accuracy is, of course, rarely necessary in stress measurement work. The method was also used by Holland (1945) for calibrating standard strain discs. This involved measuring a retardation of 23 mμ to a high degree of accuracy. Since Goranson & Adams and Holland were concerned with very accurate measurement of low retardations, the equipment they describe is more complicated than is necessary in most work on glass-to-metal seals.

The basic optical system used in the Sénarmont method is as follows: A beam of plane polarized light is produced by the light source *S*, the collimating lens *L* and the polaroid sheet *P*, which is arranged with its plane of polarization at 45 degrees to the horizontal. It is conventional to assume that the stress system in the glass at the point where the measurement is being made may be resolved into two principal stresses, one in the horizontal direction and the other in the vertical direction. The specimen G is followed by a quarter-wave plate Q, set with its axis at 45 degrees to the horizontal, and finally the light passes through an analysing polaroid which is so mounted that it can be rotated in a plane at right angles to the plane of the paper. The stress at any point is measured by rotating the analyser until extinction is obtained there, and the rotation is measured by taking as the zero position that in which the analyser is crossed with respect to the polarizer. If this rotation is θ degrees and λ is the wavelength of the light used in millimicrons, then the retardation R is given by the simple formula

$$R = \frac{\theta^\circ}{180^\circ} \times \lambda \text{ millimicrons}$$

In the arrangement used by the author, the optical system is mounted on an optical bench of 2 m length, which consists of a solid steel bar of triangular cross-section. The various parts of the optical system are carried on saddles which can be moved along the bar and finally locked in position by screws which locate in grooves that run along the upper surfaces of the bar. The light source is a 250 w mercury arc box lamp, the collimating lens *L* is a simple condenser lens of 4 in. diameter and 7 in. focal length, and the quarter-wave plate is made from a sheet of mica 1 in. in diameter (producing a quarter wavelength retardation for a wavelength of 550 mμ) sandwiched in between two glass discs.

The quarter-wave plate is mounted so that it can be rotated for preliminary adjustment and then locked in position. The analysing polaroid is mounted on a circular microscope stage graduated in degrees. A green filter *F* with maximum transmission at 550 m is used to make the light more monochromatic, but it was found that it made little difference whether this filter was used or not. Before making any measurement it is necessary to ensure that the axes of the quarter-wave plate are set correctly. This is done by crossing the polarizer and analyser with their polarization planes set at 45 degrees

(*Continued on page* 46)

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CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during October, 1959, was as follows: *Flat Glass:* a preliminary figure of 30,500 for September, 1959, indicates an increase of 0.3 per cent over the adjusted figure of 30,400 reported for September, 1959. *Glass and Glassware, Pressed and Blown:* a decrease of 6.3 per cent is shown by the preliminary figure of 83,000 reported for October, 1959, when compared with the adjusted figure of 88,600 reported for September, 1959. *Glass Products Made of Purchased Glass:* the preliminary figure of 15,500 given for October, 1959, is the same as the adjusted figure of 15,500 reported for September, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	November, 1959
Food	853,000
Medicinal and Health Supplies	1,317,000
Chemical, Household and Industrial	647,000
Toiletries and Cosmetics	748,000
Beverage, Returnable	524,000
Beverage, Non-returnable	101,000
Beer, Returnable	97,000
Beer, Non-returnable	512,000
Liquor	512,000
Wine	375,000
Sub-total (Narrow)	5,686,000

Wide Mouth Containers

Food	*2,659,000
Medicinal and Health Supplies	360,000
Chemical, Household and Industrial	113,000
Toiletries and Cosmetics	256,000
Packers' Tumblers	41,000
Dairy Products	139,000
Sub-total (Wide)	*3,568,000
Total Domestic	9,254,000
Export Shipments	272,000
TOTAL SHIPMENTS	*9,526,000

*This figure includes Fruit Jars and Jelly Glasses.

Payrolls in the glass industry during October, 1959, were as follows: *Flat Glass:* a decrease of 1.8 per cent is shown in the preliminary $17,249,066.38 given for October, 1959, when compared with September's $17,563,971.49. *Glass and Glassware, Pressed and Blown:* a decrease of 4.3 per cent is shown in the preliminary $30,997,285.41 reported for October, 1959, when compared with the previous month's adjusted $32,386,124.57. *Glass Products Made of Purchased Glass:* a preliminary figure of $5,007,561.44 was reported for October, 1959. This is an increase of 2.2 per cent when compared with the adjusted figure of $4,881,297.82 for September, 1959.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production November 1959	Stocks November 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,467,000	6,332,000
	Wide Mouth	*4,462,000	*6,576,000
Beverage, Returnable		739,000	1,852,000
Beverage, Non-returnable		118,000	231,000
Beer, Returnable		209,000	418,000
Beer, Non-returnable		757,000	818,000
Liquor		931,000	1,493,000
Wine		505,000	604,000
Packers' Tumblers		51,000	125,000
Dairy Products		202,000	276,000
TOTAL		*12,188,000	*18,324,000

* This figure includes Fruit Jars and Jelly Glasses.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 12,188,000 gross during November, 1959. This is a decrease of 9.3 per cent under the previous month's production figure of 13,450,000 gross. During November, 1958, glass container production was 11,455,000 gross, or 6.01 per cent less than the November, 1959 figure. At the end of the first eleven months of 1959, glass container manufacturers have produced a preliminary total of 141,902,000 gross. This is 5.1 per cent more than the 133,979,000 gross produced during the same period in 1958.

Glass Container Shipments during November, 1959, came to 9,526,000 gross, a decrease of 21.2 per cent under October, 1959. Shipments during November, 1958, amounted to 10,772,000 gross, or 19.9 per cent less than October, 1959. At the end of the first eleven months of 1959, shipments have reached a preliminary total of 141,097,000 gross, which is 6.9 per cent more than the 132,020,000 gross shipped during the same period the previous year.

Stocks on hand at the end of November, 1959, came to 18,324,000 gross. This is 16.5 per cent more than the 15,726,000 gross on hand at the end of October, 1959, and 2.6 per cent less than the 18,820,000 gross on hand at the end of November, 1958.

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NEW EQUIPMENT AND SUPPLIES

Silvering Machine

Eisler Engineering Co., Inc., Newark, N.J. is producing a silvering machine for various types of lamp bulbs. The device uses the wet process method for the internal silvering of 24 bulbs simultaneously. It is equipped with preliminary water wash unit, sensitizing unit for internal tinchloride wash, demineralized water wash unit, silvering unit with 24 rotating bulb nests, tap water wash unit and gas fired oven for drying acceleration. Parts are loaded manually into wood frame which moves through the washing, silvering and drying units at a production rate of 500 bulbs per hour.

Square Flask

Kimble Glass Co., subsidiary of Owens-Illinois Glass Co., Toledo, O., has introduced a space-saving square-shaped, borosilicate, volumetric flask.

The hard glass flasks are available in five sizes: 100 ml, 250 ml, 500 ml, 1,000 ml and 2,000 ml. The 1,000 ml size is said to use 38 per cent less shelf area than a conventional flask of equal capacity. The containers are stoppered with tapered, hard glass stoppers and are resistant to thermal shock and chemical attack, except for hydrofluoric acid.

Metal-Mesh Conveyor Belts

Cambridge Wire Cloth Co., Cambridge, Md., has developed a new method of manufacturing metal-mesh conveyor belts said to give greater belt rigidity and less elongation after installation and use.

The new technique concerns the development of crimp wheels with helical teeth, that crimp the transverse wire at an angle, thus producing grooves running in the same direction as the spiral wires it connects, and at the same angle as the weave.

Advantages consumers may expect from the new belt construction are: greater bearing area between crimped and spiral wires; less wedge effect between crimped and spiral wires; smoother hinging that assures smoother operation and more lateral rigidity for straighter belt travel.

Filters of Glass Fibers

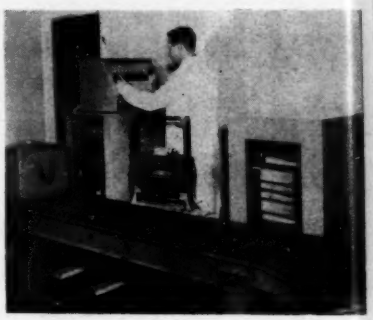
The American Machine and Foundry Co., has available two filtering materials, Fiberfilm and Amfab, made of resin-impregnated glass fibers. They are said to have the same properties as filters made of cellulose fibers and to be resistant to chemicals and to heat of 500 degrees. Fiberfilm is designed for laboratory operations and Amfab is for use in large-scale industrial processes.

Automatic Conveyor

Atronic Products, Inc., Bala-Cynwyd, Pa., is offering an automatic conveyor routing system that directs tote boxes, cardboard cartons and other containers to selected stations on a conveyor line.

The routing system can be used to direct containers to packing stations for broken lot order assembly or to direct work through various processing stations. Either single containers or "trains" of containers can be handled. Containers can be diverted at any station, processed, replaced on the conveyor and diverted again at another station for further processing.

A dispatcher at the control console selects the routes by depressing station keys and coded instructions are automatically placed on the containers by an inking printer. The code can be automatically removed at the last station if the container is to be reused.



Adhesives

B. B. Chemical Co., Cambridge, Mass., has produced three adhesives with high solid content and low shrinkage for bonding or sealing of irregular mating surfaces and porous materials. The adhesives are resistant to fresh and salt water, can be painted when dry and are said to have a high resiliency against vibration and impact.

They will adhere to materials such as concrete, fabrics, glass, insulating and wallboards, linoleum, metal, paper, plaster, felt, rigid plastic, cork, stone and wood, and need to be applied to one surface only. The adhesives are rubber base types, noncuring and gain in strength for 24 to 48 hours after use.

Pressure Recorder

U.S. Gauge, division of American Machine & Metals, Inc., has available a 12-inch recorder for temperature or pressure that measures temperatures from minus 300°F to 1200°F and records pressures from 30-inches of mercury vacuum to 25,000 psi. Aluminum door has spring-loaded hinge pins that permit removal for routine maintenance of the instrument. It can be mounted on either wall or panel. Pen movements are ball pivoted to minimize friction and wear.

Laboratory Spectroscope

Fisher Scientific Co., Pittsburgh, Pa., has developed a laboratory spectroscope said to supply a qualitative and semi-quantitative analysis of alloys, ores, minerals, soils, water, inorganic and metallo-organic compounds, and other products.

A 5-power eyepiece, inclined at 30° to the horizontal for operators in the sitting position, resolves lines as close as 3A. Dispersion is 55A/mm and the diffraction grating gives a linear spectrum making possible an accurately

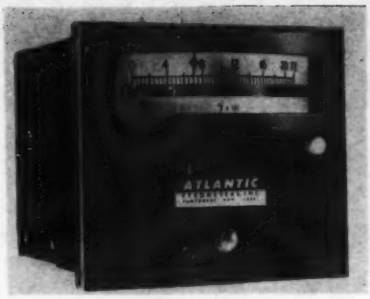
pre-calibrated wavelength scale. The wavelength of any line can be read to 5A.

The instrument occupies a square foot of bench space and is 9 inches high. Standard 75x12 mm test-tubes are used. The power supply uses a maximum of 250 watts on 115-volt, 60-cycle a.c., and is fused for 1.6 amps.

Pyrometer Controller

Atlantic Pyrometers, Inc., Hawthorne, N.J., is marketing an indicating pyrometer controller said to have both high sensitivity and high freedom from control point drifts cause by ambient effects or component changes.

The device uses a millivoltmeter measuring system. A vane type control

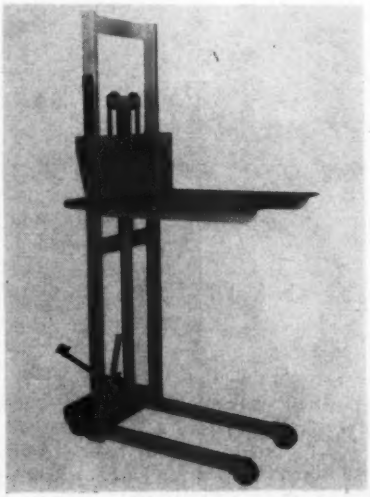


system operates an internal load relay directly and without the use of tubes, transistors or magnetic amplifiers. The component parts and wiring needed in amplifiers have been eliminated for increased reliability and almost complete elimination of maintenance. Standard ranges for all ISA thermocouple calibration types are supplied. Ranges with special calibrations for d.c. millivolt signals from other types of sensing elements are also available.

Mobile Hydraulic Lifter

Langley Mfg. Co., Inc., Cambridge, Mass., has available a mobile, compact hydraulic lifter and transport truck designed for use by one man.

The machine lifts loads of up to 750 lbs. to a height of 64 in. above floor level. Lifting speed is one inch per stroke under full load conditions. The lifter weighs 204 lbs. and has twin precision roller type chains designed so that each can carry the total load by itself. A back plate incorporated in the platform keeps the load away from the masts and chains. The hydraulic system is self-contained and equipped with a chrome plated piston for all weather protection.



CATALOGS RECEIVED

Oxygen analyzer. (4 pages) Bulletin describing use of oxygen analyzer to control glass tank excess air. Chart records show progression from full manual to full automatic control.

BAILEY METER CO., Cleveland, O.

Piping problems. (2 pages) Case histories sheet describing solution of five piping problems in industry. Covers leakage, positioning, and overtightening damage on piping connections to diesel engines, diagphram compressors, automatic door operating mechanisms, boring machines and multiple-unit gage card assemblies.

FLICK-REEDY CORP., Bensenville, Ill.

Conveyor screens. (2 pages) Descriptions, specifications and data for three standard mechanical conveyor screen models designed for scalping and coarse and medium sizing of many bulk materials. Illustrated.

SYNTRON CO., Homer City, Pa.

Data processing equipment. (48 pages) Describes data processing equipment in use on digital data processing and analog and digital computing systems. Gives types of inputs, input switching, output devices and modes of operation for applications in electric power, petrochemical, aeronautics, agriculture and other fields. Illustrated.

LEEDS & NORTHRUP CO., Philadelphia, Pa.

Data system. (12 pages) Outlines construction and operation of basic modular chassis, including plug-in housings and pin-board arrangement for function programming, of series 2000 data system. Illustrations, charts, specifications and technical data.

HAGAN CHEMICALS & CONTROLS, INC., Pittsburgh, Pa.

Test instruments. (48 pages) Catalog of instruments for scientific measurement, recording, and testing. Illustrations, specifications and references are given. Included D-C amplifiers, data handling systems, laboratory and calibration instruments, magnetic tape instrumentation, nuclear instrumentation, oscillographs, recorders and indicators, servo components, temperature controllers and transducers.

MINNEAPOLIS-HONEYWELL REGULATOR CO., Philadelphia, Pa.

NEW BOOKS

NINETEENTH CENTURY GLASS, *by Albert Christian Revi*, Thomas Nelson & Sons, New York. 270 pages, $8.50.

An authoritative study of glassware made in the nineteenth century, often called the Golden Age in the history of glass. The important types of glass of that era are described in detail, each in a separate chapter, with particular emphasis given to the history, details of manufacture, and means of identification. The author frequently refers to the basic patents concerned with each type of glass, taking particular care to trace the development of that glass, both in England and in America. Most interesting are his copious notes concerning the early glass companies in America.

In his Introduction, Mr. Revi describes the widespread use of obsidian, or natural volcanic glass, among primitive peoples and traces the history of manufactured glass from the earliest known examples of Mesopotamia, Syria, and Egypt, through the technical developments of the late classical and early Christian centuries and the Renaissance, to the end of the eighteenth century.

"The industrial revolution," writes Mr. Revi in the Introduction, "the relaxation of government controls on the industry (specifically in England), plus a pride of craftsmanship born of freedom, were a few of the contributing factors to this Golden Age of Glass. It is our earnest endeavor to graphically illustrate the visible evidences of this period in glass history and in every case where possible to acquaint the reader with their earlier prototypes."

This he has done in a most capable fashion. It is evident throughout the book that the author has a large fund of first-hand information, built up through years of research and extensive travel in this country and in Europe.

Some of the chapter headings are: Pearl Satinglass, Coralene, Amberina, Peach Blow Glassware, Royal Flemish; Smith Brothers, The C. F. Monroe Company, Richardson & Atterbury Patents for Enameled Glassware; Venetian Techniques (Millefiori, Filigree Glass, Striped Glass); Silvered Glass, Stone Glasses, Tortoise-Shell Glass; Paperweight Patents.

A number of these chapters have been published in briefer form in THE GLASS INDUSTRY: Spun Glass: *39*, 325, 1958; The Diatreta Technique *39*, 428, 1958; Lava Glassware: *40*, 295 1959.

This book is a valuable addition to any reference library on glass because of the care with which the material is presented and because of the numerous detailed photographs reproduced throughout.

A CONTEMPORARY ANALYSIS OF A LABOR UNION, *by Miles E. Hoffman*, Department of Economics and Management, Temple University, Philadelphia, Pa. 30-page booklet; no charge.

An independent study of the structure and operation of the 53,500-member Glass Bottle Blowers Association. The purpose of this report is to provide students and associates with an analysis of the development, structure and functions of an international union.

To obtain a copy, write to the Association at 226 South 16th St., Philadelphia 2, Pa.

BRITISH GLASS INDUSTRY DIRECTORY & BUYERS' GUIDE, (Seventh Edition), Society of Glass Technology, England. 376 pages; $2.

Contains names, addresses, branch offices and overseas agencies of approximately 600 firms (not U.S.) engaged in the glass industry, including a description of their products or services. Includes a geographical index with firms' names arranged alphabetically under counties or countries.

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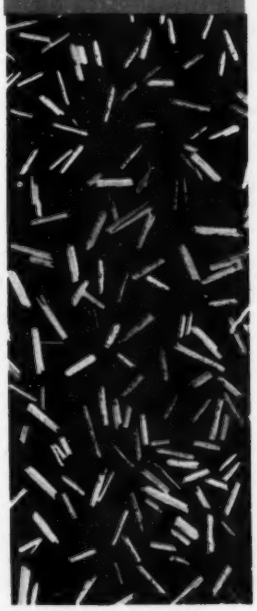

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RESEARCH DIGEST

(*Continued from page* 36)

to the horizontal, and then inserting the quarter-wave plate, and rotating it until the light intensity is at a minimum. The plate is locked in this position and the system can then be used for measurement.

The readings obtained with the Sénarmont method have been compared on a number of seals with those obtained using an Ehringhaus compensator (a rotating quartz plate compensator made by Winkel-Zeiss).

The results are given in Table I.

The Sénarmont method has now been in regular use in the author's laboratory for about six months. The author's experience is that it is an easier method to use than the method based on an Ehringhaus compensator which had been used for many years previously. Although the equipment described is set up on a commercial optical bench of reasonably good design it is consid-

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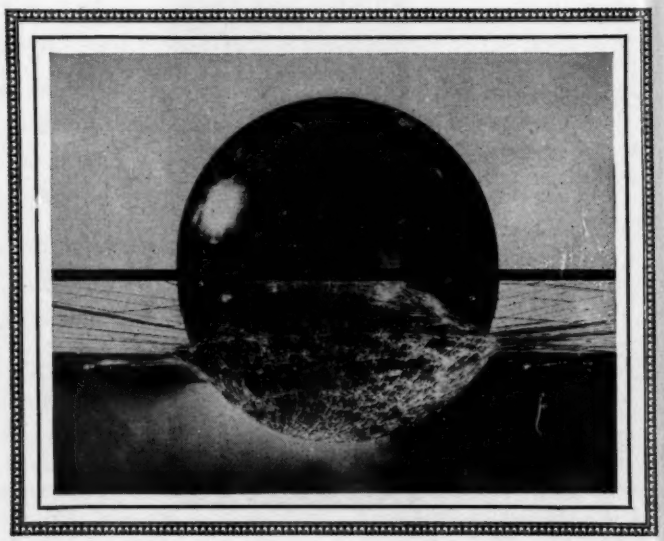

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ered that a very simple home-made optical bench would serve equally well and that the whole equipment could be built inexpensively.

Table I

SPECIMEN	SENARMONT METHOD Mμ	EHRINGHAUS COMPENSATOR Mμ
Sandwich seal 1	58	56
Sandwich seal 2	73	68
Sandwich seal 3	88	93
Sandwich seal 4	117	112
Bead seal 1	441	485
Bead seal 2	400	408

LOUIS NAVIAS . . .

Continued from page 13)

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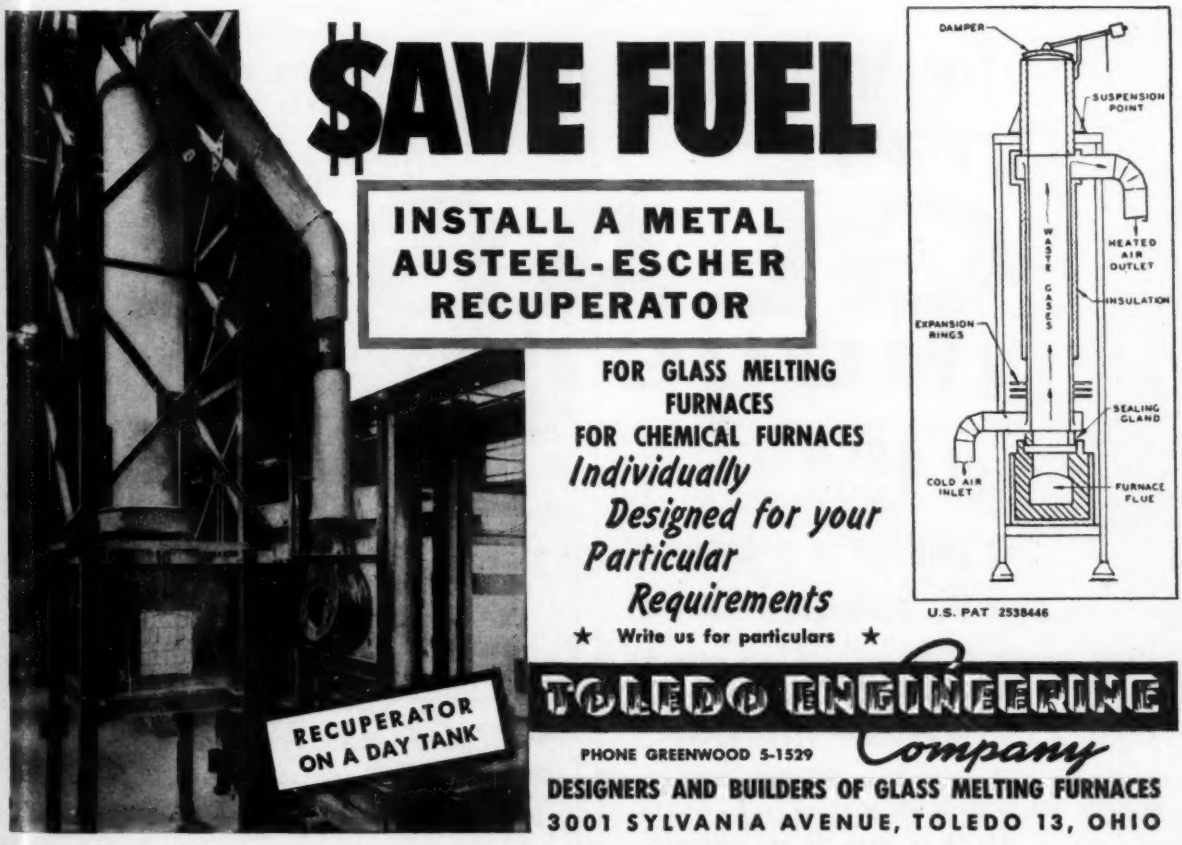

THE RARE EARTHS

(*Continued from page* 16)

by far of commercial rare earth products, only its treatment will be described. However, similar techniques are employed with other raw materials.

The extraction of the rare earths from monazite consists of four steps: opening of the ore, separation of thorium, isolation of the rare earths, and separation of the individual rare earths.

The opening of the ore is generally done with sulfuric acid, although some plants operate using a caustic soda initial treatment. In the former, ground ore is heated with up to three times its weight of concentrated sulfuric acid in a cast iron pot with stirring until the reaction is completed. This treatment forms rare earth sulfates which are dissolved by water leaching. Thorium is then removed by diluting the solution to precipitate selectively thorium phosphate, or the thorium may be precipitated with sodium pyrophosphate or with the addition of a base to precipitate basic thorium salts.

The rare earths are recovered from the solution remaining after separation of the thorium by precipitation as rare earth oxalates by addition of oxalic acid, or as sodium rare earth double sulfates by the addition of sodium sulfate. In the latter case, insoluble cerium earth double sulfates are precipitated, leaving a large proportion of the yttrium earths (see Table I) in solution. The precipitated rare earth salts are recovered by filtration and are converted to rare earth hydroxides by boiling with sodium hydroxide. Rare earth salts, such as fluorides or chlorides, are made from these hydroxides by treatment with the appropriate acid. Drying these hydroxides yields hydrated oxides, and if rare earth oxides are desired, the hydroxides or oxalates are calcined.

By referring to Fig. 1, which is a flow scheme of the separation and recovery of the various pure and mixed products from monazite, the meaning of the different designations of intermediates and products will be better understood.

Most commercial rare earth salts (Fig. 1, line 2) contain the rare earths present in much the same ratio as these elements existed in the ore. The separation of the individual rare earths from each other requires an extended additional treatment.

Cerium Separation. Cerium, the most prevalent of the rare earths, is the first one separated because it can be oxidized to the tetravalent ceric state where its properties are quite different from those of the other rare earths. The oxidation can be achieved by treatment of an acid solution with ammonium persulfate and other oxidizing agents, or by electrolysis, which do not affect the other trivalent rare earths. Separation of the cerium can now be made by the precipitation of basic ceric salts, or by the crystallization of insoluble ceric compounds such as the ammonium hexanitratocerate or the ammonium trisulfatocerate. From the latter compounds, pure cerium compounds, including ceric oxide, CeO_2, are formed.

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By another technique, cerium is separated from the other rare earths by partial dissolution of the hydrated rare earth oxides mentioned previously. When these hydroxides, containing cerous hydroxide, $Ce(OH)_3$, are dried in the air, the cerium is readily converted to the ceric state in the form of the hydrated ceric oxide and the other rare earths are converted to hydrated trivalent oxides. The partial dissolution of these hydrated oxides by acid will leave the cerium in the insoluble residue if the pH of the system is maintained below that required for precipitation of trivalent rare earths, 6.3-8.2, and above that required for precipitation of tetravalent cerium, 2.7.

It must be emphasized that no one treatment will give cerium products containing less than 0.5 to 1 per cent of other rare earths, when starting with the crude rare earths obtained from monazite and containing about 50 per cent cerium. Repetitions of the treatment or combinations of treatments will yield very high purity cerium compounds.

Didymium. The rare earth mixture remaining after the separation of thorium and cerium from the natural mixture found in monazite is often referred to as "didymium", and since this term is still used in industry and particularly in the glass industry, it will be discussed further.

The composition of this material is quite consistent since most of the rare earths are derived from monazite whose large ore bodies are quite uniform in composition. Approximate compositions of the contained rare earths in commercial didymium materials are given below:

	Regular Grade, per cent	Low Ce Grade, per cent
Lanthanum oxide, La_2O_3	45-46	46-47
Cerium oxide, CeO_2	1-2	0.1 approx.
Praseodymium oxide, Pr_6O_{11}	9-10	9-10
Neodymium oxide, Nd_2O_3	32-33	32-33
Samarium oxide, Sm_2O_3	5-6	5-6
Gadolinium oxide, Gd_2O_3	3-4	3-4
Yttrium oxide, Y_2O_3	0.4 approx.	0.4 approx.
Other rare earth oxides	1-2	1-2
	100	100

Because of the similarity in chemical properties of the rare earth compounds, a whole series of didymium "compounds" are available that are actually mixtures of the corresponding compounds of each of the contained rare earths. These include the chloride, carbonate, oxide, oxalate, hydrate, nitrate, acetate and fluoride. In addition to being useful themselves, the didymium compounds are sources of each of the individual rare earths comprising them. Applications of the didymium compounds will be discussed in future articles.

Lanthanum and Neodymium. These two rare earths, the second and third most prevalent commercially, are separated on a large scale from the didymium mixture by the crystallization of double ammonium or magnesium

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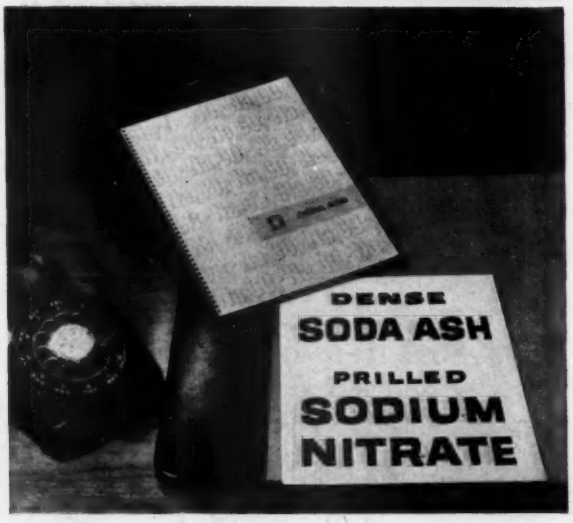

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rare earth nitrates. Very pure products of these two elements are obtained commercially by this method. The crystallizations, however, are complicated and tedious.

Other Rare Earths. The ion-exchange method is used for the separation and purification of the remaining rare earths and yttrium. A solution of these elements is fed into the top of a large column containing a cation ion-exchange resin where the rare earth ions combine selectively with the solid resin to form a salt or compound.

By elution, or washing, of the resin with a solution of ethylenediaminetetraacetate (ENTA), an organic complexing agent, the individual rare earths are successively brought into solution and spread out to form bands in a series of columns in which the resin is in the copper state. The bands containing the individual rare earths are located by analysis, and the rare earth ions are stripped from the resin in that band. Pure rare earth oxalates are precipitated from the effluent from that band and ignited to the oxides.

This method, developed in the last few years largely at the Institute for Atomic Research, Iowa State College, by Spedding and co-workers, has provided pure rare earth compounds which have opened up new fields of knowledge about these interesting, but hitherto difficult-to-obtain, elements. It has also resulted in increased availability and decreased price of the individual rare earths.

Properties

The rare earth elements are trivalent in most compounds, but cerium, praseodymium and terbium also exist in the tetravalent state. In fact this is the most stable valence state for cerium. Samarium, europium and ytterbium form divalent compounds that are easily oxidized to the trivalent state.

With the exception of lanthanum and lutetium, rare earth compounds show characteristic sharp absorption bands in the ultra-violet and visible spectra. This absorption accounts for some of the most useful applications in the glass industry, and is responsible for the pastel colors of the colored rare earth salts: green praseodymium, pink neodymium, yellow samarium and holmium, rose erbium and pale green thulium.

The common water-soluble salts of the rare earths are the acetates, chlorides, nitrates and sulfates. However, with alkali metal sulfates, double sulfates that are sparingly soluble are formed. The insoluble compounds include the carbonates, oxalates, hydroxides, oxides, phosphates and fluorides.

The rare earth elements are essentially basic in character, and show amphoteric properties only under unusual circumstances. In this respect they are somewhat like the alkaline earth elements. Their oxides all melt at very high temperatures, for example, 2600°C for CeO_2; 2350°C for Sm_2O_3; and 2315°C for La_2O_3. The densities of the oxides range from 6.5 g/cc for La_2O_3 to 7.3 for CeO_2 and 9.17 for Yb_2O_3.

Availability and Cost

For the past several years the sale of rare earth chemicals in the United States has been between three and four million pounds of equivalent rare earth oxides per

year. Most of this has been in the form of mixtures of rare earth oxides, chlorides, fluorides and rare earth sodium sulfate, $RE_2(SO_4)_3 \cdot Na_2SO_4 \cdot 2H_2O$, and in the form of cerium oxide and hydrate. Much smaller amounts of the other rare earth chemicals in varying degrees of purity have been used.

It is estimated that the current capacity for rare earth products is some 24 million pounds of crude rare earths per year in the form of rare earth sodium sulfate, the primary product from the chemical processing of ores such as monazite.

Table III lists the present productive capacity for several of the rare earths in terms of oxides. Also presented there are current prices for commercial quantities, i.e. for lots of 500 pounds or more.

The rare earth industry could expand its production without much difficulty and, along with this increased production, prices undoubtedly will become lower. Even though all of the rare earth products are derived from a single raw material containing essentially constant ratios of the several rare earths, an increased demand for a particular rare earth can be met to a great extent by removing it from one of the many mixtures now produced, without harming the value or the application of that mixture. For example, while rare earth sodium sulfate is sold as a source of cerium oxide, (containing 20.6 per cent CeO_2) for the preparation of ultraviolet glass, other rare earths present in this mixture do not aid appreciably—although they may serve a useful purpose as physical decolorizers.

The other rare earths could be removed from this product if a demand for them arose; in other words, many of the mixtures now sold could be upgraded to provide additional supplies of individual rare earths.

CARBORUNDUM TRIPLES PLANT CAPACITY

(*Continued from page* 21)

Principal use for these corrosion- and heat-shock-resistant fused cast refractories is in tanks melting virtually all glasses (Table I).

Outside the glass industry applications include sodium silicate furnaces, electrolytic magnesium cells and synthesis gas generators in all of which corrosion is a major problem. Other usage is to resist impact and abrasion in coke chutes, ball mills and various types of equipment where severe wear develops.

Table I

Crystalline Phase Composition	Designation	Batch Ingredients	Application Areas
Beta Alumina	H	Alumina Soda Ash	Throughout Superstructures
Beta Alumina Alpha Alumina	M	Alumina Soda Ash Modifier*	Refining Ends Feeder Channels and some Melters
Zirconia Alpha Alumina	S	Zircon Alumina Modifier*	High Production Melters and portions of Superstructure
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